INTRODUCTION

When it comes to bioart, in this chapter, I am addressing a possible future of what is slowly becoming to be taken more seriously by global institutions of art and design, perhaps less so by art|education. Yet, there is little to no place for bioart in universities and public schools as they presently stand. I was fortunate enough to experience a taste of what bioart offers at the Biofilia initiative situated at the School of Arts, Design, and Architecture, University of Aalto, Finland, in December 2018. While my experience was somewhat impoverished as I did not have a residency there, it did offer me some insights regarding CRISPER-Cas9, and my participation occurred at the very same time that news came that a Chinese doctor, He Jiankul, had gene-edited two babies: Lulu and Nana. Video conferencing and discussions with leading bioartists (Marta de Menezes ran the lab at this time) furthered my grasp of what had just happened.

Bioart might be identified as a relatively insignificant, if not minor development that is inaccessible to most of these institutions: the ethical and political questions that this development raises, as well as the procedural protocols that are required for the production of ‘life’ are simply

A version of this chapter was published in Journal of Research in Art Education 20(1), 2019.08, published by Korean Society for Education through Art.

© The Author(s) 2020
j. jagodzinski, Pedagogical Explorations in a Posthuman Age, Palgrave Studies in Educational Futures, https://doi.org/10.1007/978-3-030-48618-1_11
too worrisome and too expensive for art and design departments, and
certainly for public schools. In short, while a large body of literature now
exists examining the wide range of bioart installations since the turn of
the twenty-first century, bioart remains idiosyncratic and marginal in
relation to the dominant trends pursued by art and design departments
where the turn has been toward the do-it-yourself (DIY) entrepreneurial
spirit of ‘maker culture’ or ‘makerspaces’ as a way of meeting capital-
list market demands (Rosenfeld and Sheridan 2014). In what follows,
I will make a distinction between bioart as a minor development and
BioArt as a ‘minoritarian’ development in the field of art and technol-
y. Minoritarian BioArt will refer to those artists and their explorations,
which directly question the bioengineering that is underway where many
bioartists are playfully manipulating DNA of species (plants, bacteria, in
some cases animals) more for aesthetic ends that ethico-political con-
cerns. The manipulation of the human genome being the most egregious
act possible.

Historically, at the turn of the twentieth century, as it can be
recalled, art|education in schools was directed primarily at mechanical
and realist drawing targeted for vocational training to meet industrial
demands of international capitalism at that time. At the same time, the
art-world was flowering in new ideas, exploring changes in the world
order that demanded a new understanding of time and space. The
proliferation of various isms: Expressionism, Impressionism, Cubism,
Fauvism, Surrealism, Dadaism, Futurism, Vorticism, Constructivism,
and Suprematism, came to be collectively known as Modernism. These
movements were tuned to the scientific developments of the day,
especially the fourth dimension of time, its relativity, and speed as Linda
Henderson (2013) has brilliantly shown.

Modernism decentered the meaning of art, which was entrenched in
mechanical thought, not only in public schools but also in art galleries and
museums around the world. It was not until the 1950s, after World War
II, that these modernist ideas were finally introduced into public schools
in both North America and Europe, primarily through Expressionism
where individualist artistic subjectivity overcame the mechanistic objec-
tivity of drawing for industry. This development is often referred to at the
beginnings of art|education. By this time capitalism had expanded into its
post-international phase requiring higher education to meet the new indus-
trial needs for the job market. Adolescence was ‘invented.’ Colleges and
universities began to flourish (Fasick 1994).
In the contemporary world, we find another decentering of art taking place that incorporates science and technology. Much has already been written about bioart, yet I hope to bring something new to this development by showing why its decentering force and the questions concerning life that is raises have become so important given the state of the ecological crisis—the so-called Anthropocene that my subtitle alludes to: ‘thinking the end of times.’ By this turn of phrase, I mean that the ontology of the way we understand ourselves in relation to the Earth has changed. It is a recognition that both nonhuman (both organic and inorganic life) and inhuman (artificial intelligence, technologies per se) have agency. Their agency has historically shaped ‘human cultures’ as they profoundly affect what is defined as ‘human,’ an inclusionary category that has excluded women, children, ‘primitives,’ animals, and so on in the history of humankind. In the previous chapter, I referred to the way the original synaesthesia of the infant is subject to manipulation via technologies, a cyborgian development. It is possible for the ‘tongue to see,’ enabling the blind to experience unprecedented sensations (Weibel 2015).

Bioart exceeds the computer digitalization that initiated a posthuman future in the 1970s and 1980s—the so-called dryware influences of cybernetics, information theory, and discourse analysis where research stressed language as the key to ‘reality,’ often referred to as the ‘linguistic turn,’ which pervaded the academy in the last quarter of the twentieth century (Toews 1987). With the advent of DNA research at the turn of the twenty-first century, the focus has turned to ‘life.’ What is life? Can it be created and changed? Bioengineering introduced an accelerating dynamic between cultural and genetic evolution—a co-evolution between technical knowledge and an understanding of living matter. Technogenesis refers to the interactions between technology and biology—the way this development impacts on our understanding of nature, and the way nature can be manipulated and reconfigured in and for the future (Stiegler 1998; Hayles 2012). Eduardo Kac (1998) coined the term ‘transgenic art’ when referring to this development (Savini 2017). Today bioart or sci-art has injected ‘wetware’ into this former ‘dryware’ development of the 1990s. The twenty-first century, often cited as the ‘biotech century,’ is framed by biopolitics and biotechnologies that are integrated and informed by algorithms, which, through transcribed programs, set limits and scenarios as to the possibilities when it comes to creating life (Rifkin 1998).
At the turn of the twenty-first century, in 1999 and 2000, bioart also made its appearance by exploring ‘life’ as its medium, just like stone, clay, paint, metal, and other materials were understood as artistic media or mixed-media, introducing what a host of critics, art historians, and curators eventually called a ‘post-media condition’ or ‘post-medial condition’ (Guattari 2009; Krauss 2000; Manovich 2000; Quaranta 2011; Weibel 2012). The scientific understanding of a medium is a substance that enables bacteria and microorganisms to grow. Overlaying this definition is the added idea of media itself, which is pertinent to the imaginary in both art and science. Which is to say that images, located somewhere between illusion, proof, and cognitive projection, have become critical fictions that operate within a cultural imaginary. Three overlapping meanings of media|medium thus emerge: media as a sense of milieu (growth in petri dishes for instance), media as a means of transformation or generation (the ability to transmit, store, and process to produce genetically modified organisms), and, lastly, media as instances of measurement, especially where one biological entity is capable of measuring another. Best examples include Green Fluorescent Proteins (GFPs) as biomarkers and gel electrophoresis where DNA molecules are cut by enzymes to locate genetic sequences: hence the post-media condition. Fact and fiction are blurred as visual models in art, science, design, advertising, and journalism, clarify, mislead, stimulate, and aggrandize reality, often referred to as a post-truth era, as discussed throughout previous chapters as ‘powers of the false’.

**Genesis**

I will take one well-known and famous example of bioart performed in 1999 for the Ars Electronica in Linz, Austria, to illustrate the importance of this development where a collapse between art, science, and technology takes place—where ‘dry’ digital information is linked with ‘wet’ biology via biotechnology, which is also overlaid by media (usually video, image projections, photography, film). This would be a prime example of BioArt as it questions the bioengineering of life. One of the foremost pioneers of BioArt is the Brazilian artist Eduardo Kac (2007a, b, c), famously known for his GFP [Green Fluorescent Protein] Bunny (a genetically modified rabbit that glows a bright green under ultraviolet light). This ‘rabbit’ illustrates an early form of technogenesis, raising questions as to what precisely is creativity and creation. When Alba, the name of the bunny,
was displayed in 2000, both scientists and animal activists protested; the scandal that biotechnology could be used for an art exhibit, regardless of how harmless, drew sensationalist reporting and shock. It often appears as the primary exemplar of the bioart genre in various ‘histories’ of art.

What became significant was Kac’s exploring the question of genesis as linked to genes: the complex DNA sequences with their potential to create mutant biomorphic creatures. Kac explores the boundaries between humans, animals, and robots, in my vocabulary the relations between the nonhuman (organic and inorganic matter) and inhuman (AI or artificial intelligence of any degree like biobots). DNA’s double-helix structure was discovered in 1953 by David Watson and Francis Crick, and was quickly elevated and given special status in relation to cracking the code of life, leading up to the Human Genome Project (HGP) that was to chart the entire human genome—a complete and accurate sequence of the 3 billion DNA base pairs, some 20,000–25,000 human genes. This project was started in 1990 and completed in 2003. DNA was then quickly linked to identity, heritage, and immortality. DNA testing was used to ‘discover’ bio-historical ancestry, family identity and genealogical connections, paternity testing, and even linked to personal gene therapy. To ascertain one’s genealogical gene history, all that was needed is a sample of one’s saliva sent to any one of the many companies who do the analysis (MyHertiage DNA, Ancestry, Living DNA, GPS Origins), and ‘presto,’ your ancestry is magically revealed! Unfortunately, much of these findings remain bogus. Assurances of DNA testing began to be plagued by the ecology of gene life, commonly known as epigenetics where the modification of gene expression was not so easily predicted as once thought.

The second phase of genetic engineering that followed became known as ‘recombinant DNA,’ essentially all this meant was a ‘cut and paste’ technique, or ‘dice and splice’ gene sequences to form a mutant collage—inveting new forms of life such as transgenic bacteria, mice, fish, and Kac’s GFP Bunny. This is where Kac’s installation called Genesis comes in, setting the stage for the next 20 years. Kac’s installation Genesis (1998–1999) explores the feedback loop between computers (algorithms) and biology that is central to current genetic engineering. The artwork focuses on three acts of coded translation, which are then reversed. The flow chart of the Genesis installation goes as follows: a Biblical sentence is translated into Morse Code, and the Morse Code is translated into synthetic DNA, which is then subjected to ultraviolet
light enabling it to mutate. This process is then reverse-coded back to a modified Biblical sentence. The first act is to translate a sentence from an English version of the Old Testament:

Let man have dominion over the fish of the sea and over the fowl of the air and over every living thing that moves upon the earth.

Obviously, Kac chose this sentence from the Biblical Genesis to show the anthropocentrism that defines our species—it’s central place as the apex of all life.

The second translation was to take the sentence and change it into the binary system of Morse Code, a series of dots and dashes. For Kac, the Morse Code binary was first employed in the nineteenth century and extensively used in radiotelegraphy. Morse Code represents the dawn of the information age—a dry information medium based on the Latin alphabet and extended to include other languages that have more than 26 letters.

The third translation is to convert the resultant Morse Code into a DNA sequence—a genetic alphabet: GATC. This is an arbitrary code that uses only capital letters: G, A, T, and C. Within molecular biology, G, A, T, and C function as a textual shorthand for the four nitrogenous (chemical) bases within a DNA molecule: guanine, adenine, thymine, and cytosine. These four base chemicals interact with a phosphate group and sugar that are the same in all DNA nucleoids. While such chemistry is difficult to grasp, unless you are a geneticist, Kac sent this line of text to a laboratory where technicians linked these four DNA bases—guanine, adenine, thymine, and cytosine (GATC)—to form a ‘synthetic art gene.’ Many bioartists make themselves familiar with the biochemistry of cells, bacteria, viruses, and so on. Through Internet research, they are able to ‘download’ in many instances the complete genetic code of an organism they are working with.

When Kac’s ‘text’ was translated or transcribed into a DNA sequence by an outside lab, what emerged was what Kac called an ‘artist’s gene,’ or ‘Genesis gene,’ which was synthetic, artificial, and arbitrary. The next step was more complex for it involved molecular cloning. The artist’s gene was placed into a petri dish next to a protein called ECFP—a protein that emits a cyan fluorescent light under ultraviolet radiation. The artist’s gene now became color-coded through this interaction.
This color-coded engineered artist’s gene was then inserted into a species of *E.coli* bacteria that lacked the artist’s gene. This colony of *E.coli* was color coded with an Enhanced Yellow Fluorescent Protein (EYFP) that emitted yellow light when exposed to ultraviolet radiation. A mutant gene developed through this interaction which underwent color changes.

For the interaction to occur, the two strains of cyan and yellow bacteria were placed in a petri dish with a medium that encourages their growth. A video projector and ultraviolet light were placed above the petri dish so that spectators were able to see an enlarged image of the mutant bacteria in *real time*. The bacteria replicated every 20 min. The audience could visualize both the inter- and intra-generational movement of *Genesis*’ genetic sequence. It was possible to monitor how the bacteria retained or lost their respective color, as well as how they produced a hybrid green. Participants in the gallery space could go online and manipulate the amount of ultraviolet radiation that enabled the gene to mutate. Outside observers could do the same by logging on to the installation’s website and view the changes that were taking place.

Such interactive ‘telepresence’ (the virtual reality or streaming media created by the Internet) is common to bioart installations. Spectator-participants could alter the amount of ultraviolet light to which mutant *E.coli* were subjected to. Kac called this ‘transgenic bacterial communication.’ By switching the ultraviolet light off and on, the DNA sequence was disrupted in the plasmid. Ultraviolet light accelerated the mutation rate and visually changed the colors that were projected on the wall.

The installation, for Kac, had an ethical purpose: not only to question man’s dominion over nature, but also to exploit the feedback loops between dry information and wet biology. It was possible, at the end of the first *Genesis* exhibition at Ars Electronica to translate back the modified DNA of the artist’s gene into Morse Code and then back into English. The new sentence read:

> Let aan have dominion over the fish of the sea and over the fowl of the air and over every living thing that loves ua eon the earth.

The Judeo-Christian message has been altered. The word ‘Man’ had become a nonsensical signifier and the sentence transformed—a small gesture to be sure, but one of ethical significance. It was Kac’s way of
questioning the ‘god-complex’ that bioengineering presents. Kac’s installation, *Genesis*, shows that ‘life’ is very much unbounded, contingent, and subject to chance events where mutations occur (Causey 2002). When spectator-participants are placed in a ‘disembodied’ position based on their telepresence through computer-mediation, their interactions with ‘living material’ force an immediate encounter that has strong affective resonances, soliciting feelings of disgust, sympathy, anxiety, and bewilderment.

Kac’s BioArt brings together a ‘convergence’ where physical material (life in this case), dryware (information, code, patterns), and meaning ware all come together. Meaning ware in this case is less what a BioArt installation means, as in representational epistemological discourses, but more to what is ‘does.’ What are the affects on the spectator-participants? How are they affected and changed? The ethical question of *Genesis* concerning creation and creativity was not only raised by Kac at the turn of the twenty-first century, but also by a group of cyber-artists and theorists who became collectively known as Critical Art Ensemble (CAE). In 1999, they presented a performance/installation called *Cult of the New Eve* (CoNE). They drew a parallel between two historical periods: the first is the period of Catholic Church dominance, and the current era characterized by bioengineering. DNA was extracted from the blood of an anonymous volunteer. This DNA was then copied and mass-produced. It turned out that the donor was a woman from Buffalo, New York. She became the ‘new eve’ of the second Genesis as she was the first person who donated her genes for the Human Genome Project. During the presentation, members of the audience were asked to join them in an act of molecular cannibalism: CAE offered beer and biscuits that were made with genetically modified yeast containing human genes!

In yet another work around the same time, Italy’s Societas Raffaello Sanzio theater company, under the direction of the acclaimed theater director Romeo Castellucci, wrote and performed *Genesi: From the Museum of Sleep* in 1999 that echoes both Kac and CAE in the way the work represents the emergence of a New Eve. In the first part, Madame Curie’s discovery of radium is juxtaposed against Eve’s expulsion from the Garden of Eden (Causey 2001). The point of genesis in these works of art, like Alba Kac’s GFP Bunny, is that a new line of life has emerged: what are the consequences?
CONSEQUENCES

I have spent some time mapping out Kac’s early work *Genesis*, which has been followed up by two decades (20 years) of bioartists exploring the implications of life as an artistic medium. Here are some startling considerations that have yet to be fully grasped when it comes to the posthuman condition: all of which will impact the way we view art|education in the near future.

*There has been a blurring between art and science;* science also includes technology and the importance of algorithms that both predict reality by sifting through Big Data and their cybernetic use that limits the future. This is why bioart enables a speculative endeavor since such experimentation is not obligated to scientific research, nor must it follow a set scientific methodology, nor must bioartists answer to the demands of industry—especially ‘big Pharma.’ We all have heard about the entrepreneurial emphasis of STEM (Science, Technology, Engineering, and Mathematics). Adding A—Art—to make it STEAM means little if the ethical and political direction of such research is not considered. Video games are already a good example of STEAM gone awry where entertainment for profit is developed. Of course, there are exceptions.

*Bioart blurs the line between art and non-art:* bioart draws on two previous art historical developments. The first is the ready-made by Duchamp, with an important proviso. Art as life within the gallery and life as art outside the gallery have become indistinguishable. Considering the first, art as life within the gallery, sees the ready-made in Duchampian terms. The use of living beings and tissues as artistic media is plausible because it reframes biotechnological tools and techniques as ‘ready-mades’ within the space of the gallery. The artist is less an autonomous ‘creator’ and more of an agent who selects objects from the realms of non-art and brings them into the space of the gallery. For Duchamp, this was to bring in industrialized commodities into the gallery; for vitalist bioartists, this means bringing in ‘real’ biotechnology into the gallery space and using the gallery to establish the art status of biological experimentation—petri dishes, bacteria, sustaining media, incubators, and so on. This is especially true of tissue culture, as famously grounded at the turn of the century by Ionat Zurr and Oron Catts at the SymbioticA lab founded at the University of Western Australia in Perth (Catts and Zurr 2007). They were the first to recognize that the ‘look’ of their lab within the gallery had to significantly differ from a regular science lab. This meant designing their own glassware.
The question of biomimesis: Ready-mades also begin to appear outside the gallery as well, blurring the distinction between gallery space and its outside. Here questions are raised about the genetically modified organisms and grain crops (GMOs), and the development of new species of plants and animals, which are used as ‘pollutant sensors,’ engineered using Green Fluorescent Protein (GFP) enabling them to act as biosensors (like the proverbial canary in the coal mine indicating dangerous levels of methane or carbon monoxide) (Johnson 2017). Can these developments also be identified as ‘bioart’ where the emphasis is placed on design and technology? It raises the way designer capitalism has aestheticized the entire Earth, commodifying and aestheticizing anything that can be sold for a profit based on nature’s design. We have the entire development of biomimesis which does precisely that. Not all of which should be dismissed, however most of the projects are not for a ‘commonism’ (Dardot and Laval 2019), but for profit and patent rights.

The question of performance: Besides the ready-made, bioart draws on the tradition of performance art or ‘live art,’ where affect becomes a key factor: how are bodies of spectator-participants affected by the bio-performance? Again ‘art is life’ and ‘life is art’ of the gallery and its outside become indeterminate. Historically, in the 1960s and 1970s artists such as Joseph Beuys, Allan Kaprow, and Chris Burden extended art beyond the space of the gallery and undercut the distinction between artists and spectators (Mitchell 2010). These works existed only for the duration of the event rather than persisting as objects that could be collected and purchased. Art and life become blurred yet again. Spectators became involved in completing bioart installations, which often puts them in a position of uncertainty: what am I to do? Is the performance now over? Spectator-participants are encouraged to think of themselves as part of the artwork itself.

Bioart moves the performance to living matter producing an intensification of ‘liveliness’ and ‘happening’ both in the gallery and outside it. Within gallery spaces, the pioneers of tissue culture, Ionat Zurr and Oron Catts form one of the most prominent collectives: the Tissue Culture and Art Project (TC&A). They have been growing evocative transgenic organisms or ‘semi-living sculptures’ or ‘partial objects of life’ or ‘tissue sculptures’ since 1996, bioengineering tissue organisms that are in composition with non-living materials (biopolymer scaffolding). They, like Kac and Critical Art Assemblage, have staged sci-art experiments where the audience are encouraged to participate
in the unfolding dynamic. Like Kac’s *Genesis*, spectator-participants can manipulate the growth of mutant genes. At the end of *Disembodied Cuisine*, one of TC&A’s (2003) more controversial performances, the spectator-participants were asked to collectively consume a ‘victimless steak’ they had grown. They have also grown frog steaks, pig wings, and auxiliary ears. TC&A are BioArtists in relation to the distinctions I am making. They hold a minoritarian position in the field of bioart, along with many ‘bio-hackers’ who are questioning the powers of bioengineering. The writings of Jens Hauser (2017) address this phenomenon.

*The blurring of artist and audience, or artist and machine:* Artificial intelligence of one degree or another is a strategy that enables an encounter with ‘life’ to take place. BioArt problematizes the binary distinction between life and death, that is to say, living and the non-living, organic and the inorganic. TC&A’s (2000) tissue experiments challenge the question of human/nonhuman animal relationships—the hypocrisy of anthropocentrism and speciesism (i.e., human species superiority allowing the exploitation of animals). One striking example is *Victimless Leather* (2004). TC&A experiments are prone to failure. The aesthetics of failure is very much part of the process as, often, the tissues that are grown in the art-gallery-lab become contaminated with bacteria, viruses, or fungi and then die, confirming, time and time again that the tissue membrane mediates the inside from the outside and vice versa. Failure belongs to all forms of bioart, but not to the engineering designer’s mind that must solve problems. (I personally experienced this failure during my time spent at Biofilia. All the experiments turned out to be failures!) TC&A establish a ‘quasi-ritualistic’ protocol at the end of each performance that effectively kills the tissues. The audience-participants are put in an active position concerning the performance of life and death, and the ethics and responsibility that go along with it. This is not atypical of their BioArt performances. In 2001 Critical Art Ensemble staged *GenTerra* where audience-participants faced the decision to release or ‘kill’ the grown *Escherichia Coli* bacterium with its genetically modified DNA. Although this bacterium was rather harmless and benign, the audience did not know this, but had to face the consequences of their decision with all its risks and responsibilities.

*Time limits?* What is death when it can be suspended or terminated at will? Is it then murder? The character of semi-living organisms where technology and biology come together is characterized by a ‘process of duration,’ a time limit. Recall, the science fiction film *Blade Runner*...
where the replicants (sophisticated AI clones like one sees recently on the television series *Westworld*) strive to stop their life from being terminated at a specific year, date, and time; they have a limited shelf-life, like the living tissues that are created in bioart experiments. But, there is also a plasticity that pervades these semi-living organisms: they can be altered, transformed, and manipulated without resulting in ‘death,’ a certain ‘immortality’ pervades cell lines and tissues grown as generations of stem cells and bacteria are maintained through mutations. The metamorphosis and transformations that characterize life show that it is unpredictable, unbounded, and not controllable. Semi-living BioArt presents monstrous hybrid mutants that are positioned somewhere between the living and the non-living, between the organic and the inorganic; they are part-bodies, not completed in any way. The spectacularized mutant sculptures of Patricia Piccinini are perhaps the projections of such a future? A new category emerges when technology sustains life: ‘life beyond life’ or a ‘suspended death.’ Catts and Zurr call this a ‘meta-body’ or an ‘Extended Body,’ a fragmented body that can only survive by technological means.

Such a concept does not only apply to tissue culture BioArt. I am reminded of Marc Dion’s *Neukom Vivarium*, installed in 2006, located in a specially constructed greenhouse space housed in the Olympic Sculpture Park in Seattle Washington, another example of a semi-living creature—an ‘extended body,’ this time a rotting hemlock tree, dragged from its environment and put on life-support systems through high-technology so that an entirely new ecology would develop within its artificial environment. Again, audience-participants are encouraged to interact with the tree to learn how its ecology is sustained, raising questions of speciesism and anthropocentrism.

**Resurrection**: Bioart also raises the question of ‘resurrection,’ the immortality factor mentioned earlier. What to make of the current genetic engineering projects to clone back to life species that have gone extinct, pejoratively called ‘resurrection ecology,’ ‘species revivalism,’ and ‘zombie zoology.’ The preferred term is *de-extinction* where, Revive & Restore, the name of the firm that has the capacity to do such genetic engineering, presents its mission statement: “to enhance biodiversity through the genetic rescue of endangered and extinct species.” This is the revival of what is dormant life or necro-life, life that is like death, an afterlife that continues to fascinate us through the figures of the living dead (zombies), the undead (vampires), disembodied spirits (or
phantasms), and possessed life by demons. Resurrection just does not go away, nor does the long-standing fascination with this possibility as the *Jurassic Park* film franchise shows us, which projects its sixth film in the series in 2021.

**Natalie Jeremijenko**

In the above section, I have spent some time indicating BioArt that is performed within art gallery labs that worries bioengineering, but what about outside: life as art? The foremost exemplary BioArtist here is the campy technological aesthetics developed by New York professor Natalie Jeremijenko, who converges inhuman (AI technologies like biobots), nonhuman agencies (animals, plants, inorganic minerals) with human interaction to form assemblages of affect that make a difference to the health of the environment, and to our species in general. Jeremijenko has set the path and the standard for what many BioArts have come to develop further: her reversal of anthropocentrism is that we are the ones who must listen to the voices of the nonhuman other, to co-habit with then in healthy environments.

Jeremijenko achieves this by constructing interspecies technologies. In her TED talk, *The Art of the Eco-Mindshift* (2010), Jeremijenko unveils her vision to confront the global healthcare crisis, the major environmental health issues culled by interviewing New York physicians. The idea behind her founding the Environmental Health Clinic in NYU is to turn the table around between humans and the environment; human well-being requires a healthy environment, and so ‘(im)patients’ who visit her clinic, so named because nothing environmentally is ever done quickly enough, are given ways they can actively intervene to make changes. But this intervention is somewhat absurd, ironic, campy, and whimsical—almost laughable—yet oddly scientific and soundly engineered, supported often by sophisticated technological interfaces and the telepresence of media.

An example of her interspecies technology is *Tadpole Bureaucratic Protocol* (Jeremijenko 2007, 2009). Tadpoles are treated as a companion species, each named after a local bureaucrat of the Department of Environmental Conservation, whose decisions affect water quality in NY; each tadpole is thus given a personhood. A ‘tadpole walker’ is developed, a stroller with a tadpole in a glass container that can ‘inquire’ into the local water quality when released. The idea is to stroll NY streets to do
some testing. Tadpoles have exquisite biosensors to respond to industrial contaminants of endocrine disruptors and t3-mediated hormone emulators—ingredients in personal care products, cleaning products, BPAs found in plastics and canned food containers, pesticides, antibiotics, and hormones fed to farmed animals.

These toxins find their way into the local water supplies and then into the oceans, putting aquatic animals and fish in danger. The idea of such a seemingly outrageous act of taking a tadpole for a stroll is to have neighbors or anyone on the street ask what’s going on so that the tadpole walker can explain the issues regarding water quality. Tadpoles use the same mediated hormones as humans, so a network is established between humans and nonhumans to see how each tadpole is getting along. The link to the endocrine disruptors is made to the bodily changes young girls are undergoing: the falling age of puberty, obesity, and breast cancer. Once the social network is established and the ‘health’ of the network tadpoles is assessed, it is possible to approach the local bureaucrat with evidence to insist on environmental policy change. Tadpoles are used here as a sensitive bio-monitoring device, and one assumes ethically (as well as politically) in the assemblage created.

It should be pointed out that animals of all kinds have been instrumentally employed in the same capacity as these tadpoles, like canaries in mines. A whole new technology of genetically modified plants and animals is emerging in the new field known as biosensing: the others being biomimicry and synthetic biology (Ginsberg et al. 2014). Such a trajectory of animal capital expands the more-than-human sensorium, reinstating an anthropocentric worldview where plants and animals become ‘pollutant sensors’ (Johnson 2017). In Jeremijenko’s case, tadpoles are given ‘citizenship’ and personhood. Being vulnerable to toxicity, they are able to produce knowledge and metrics regarding their condition that can be ‘shared’ for changes to the quality of water consumed in NY. They are not instrumentalized solely toward human ends; they are given agential powers. Humans are affected by them in turn.

Jeremijenko’s ethico-political stance is quite unlike genetically modified plants using GFP as an environmental biosensing pollutant indicator, or LimCo BioSensor System (LBS) that uses multiple species whole body organisms to monitor fresh and marine life water sources for pollutants. Such mimetic developments are in direct contrast to Jeremijenko’s (2007, Jeremijenko and Dehlia 2017) project TREExOFFICE. A tree is recognized for the agency of its sentience, consonant with Bolivian
Universal Declaration of the Rights of Mother Earth, which became a law in 2010. The tree acts as its own landlord; it has property rights in the space it occupies in the city. With the technology provided, humans become its tenants who pay rent by using it as a workspace or office for freelancers. The proceeds then go to the tree that ‘determines’ if its soil needs augmentation, or if other trees should be planted, giving it a self-monitoring agency, capitalizing on the resources it receives. So, personhood is bestowed on nonhuman and inhuman worlds, recognizing their agential contributions to the nonhuman, inhuman, and human assemblages that are symbiotically formed. Agential contribution does not refer to full individual agency, but is ‘distributed’ over the assemblage itself.

Thinking the End of Time

In this last section, I wish to address the subtitle of my chapter: *Thinking the End of Times*, the health of this planet and ourselves as they both constitute one another. It is well known that the Anthropocene, better known by its euphemism as climate change, is heading in the direction of our species extinction. With the COVID pandemic spreading, the ecological crisis is made that much more acute. Educational thought for the future should take seriously what BioArts are exploring. There are many who have specifically focused on viruses through their art installations, including Ebola, HIV, and Zika, under the rubric ‘microbe art’ ([https://www.virology.ws/art/](https://www.virology.ws/art/)). For the future of education, if there is to be one, this requires a collapse of subject areas, most broadly of course as science/technology with the humanities, which have been separate cultures. Perhaps more so, it requires a rethinking of subjectivity—posthuman as a new relationship with Nature, a decentering of humanist anthropocentrism, and a serious questioning of speciesism to provide an understanding of ontogenesis (the processes of becoming) and not fixated on ontology (the states of Being). Art, science, and philosophy must come together in ways that minoritarian BioArt (transgenic) art has begun to show us. Why is this so important?

While art|education remains buried in humanist issues, issues that are defined by states of justice and equality, and science is busy generating new commodities and drugs to sustain the capitalist global economy, which of late has turned to the selling of extremely potent opiates, like Fentanyl, via the Internet for safe post-delivery to anywhere in the
world. There is little talk in our schools of a future imaginary that has a different relationship with the Earth, and a different use for the technologies that have been developed. The COVID pandemic is a wake-up call to the business as usual approach. There are major questions concerning surveillance and identity as face profile recognition systems can track every moving body. The fear is that this pandemic will only strengthen such tracking systems, to identify the ‘zombies,’ so to speak. The question of identity is a crucial one when it comes to BioArt. Who owns your DNA? Who has the right to trace your biological body as your electronic one has already been captured? The Chicago-based BioArtist, Heather Dewey-Hagborg is able to 3D print faces based on the DNA sampling alone, which she finds on gum and cigarette butts. The masks that are produced are startling look-alikes of the actual persons as Heather Dewey-Hagborg’s own self-experiment confirmed. Ironically, like many BioArtistic tactics, Heather Dewey-Hagborg has marketed a spray to mask one’s DNA. It works, of course, but it is highly impractical and somewhat ‘useless,’ not unlike the technogenic tissues produced by TC&A, Kac’s glowing green bunny, and quintessentially Revital Cohen and Tuur van Balen’s *Pigeon d’Or* (2010) genetically altered gut bacteria so that pigeons would only defecate soap, or better still, their 75 Watt performative piece (2013) where a useless commodify is manufactured on an assembly line! These experiments are meant to raise ethical and political issues and not become useful for capitalist industries.

When it comes to the Anthropocene, ‘Thinking the End of Times’ has largely resulted in the instrumentalization of nature, perhaps the fastest growing area is known as biomimesis where species are bioengineered with a terminal life to do their job within an ecological environment—like the genetic modified plants mentioned earlier, the biosensing animals and plants and new synthetic bacteria that will eat plastic and make alternative fuel sources to replace the world’s dependency on oil. The vision is the complete control of life as a commodity, including terraforming and eventually leaving the plant for another—like in the dystopian film—WALL-E. Nanotechnologies, synthetic biology, cloning technologies, in vitro insemination, geo-engineering, cognitive engineering (smarter kids), and neuro-engineering that, at times, come close to neo-eugenics, brain imaging—and the entire restructuring of the body which I have not mentioned (breast augmentation, thigh and buttock lifts, penile enlargements, transgender operations, and so on)—are supposed to guarantee the future and control over living matter so that life is monopolized.
These are the extreme views of transhumanism within a posthuman world order where the end goal is to produce a modified cybernetic body. This results in the twin fears of bioerror and bioterror. A plethora of companies have already applied for over 100,000 patents on genes and parts of genes. Biotechnologies, Big Pharma, and reconstructive surgeries are all directed toward the anthropocentrism of Man and establishing the exclusivity of our species as to what is considered human. It is this engineering mind-set toward Nature that BioArtists are pushing back against through their useless, ironic, flippant, and campy aesthetics, hoping to have audience-participants encounter ‘life’ in such a way that at least a hesitation in their thinking takes place.

BioArt subverts any distinction between different fields that public schools and universities still pursue: art is separate from science is separate from language arts is separate from mathematics is separate from music and so on. BioArt carries the potential to examine possible futures—especially the techno-scientific engineering claims and the ethico-political concerns that this view brings. BioArt shows that life is unbound. This is an understanding of life as passive vitalism, uncontrollable, where mutation and unpredictability occurs. Such a position is contra to an active vitalism, which follows the dominant hylomorphic understanding of matter developed ever since Aristotle. Hylomorphism is the view that Man imposes from over matter; that matter is passive, unable to respond, only to be formed. In short, the active vitalism of matter supports the belief that technology can control matter and impose form on it without life’s excess ‘escaping’ in directions it so wishes. An interesting film that shows this very paradox is Life (2017, Daniel Espinosa), a sci-fi horror film where scientists discover a new life form, and think that it can be tamed. Like most dystopian films, things go awry!

**Biophilosophy**

I have avoided spending time discussing the philosophical shift that is necessary in understanding subjectivity that is required in order to move education out of its humanistic and technical instrumental mind-set. Previous chapters have already done this. Eugene Thacker (2008), currently professor at the New School in New York City, has usefully made a distinction between the philosophy of biology and biophilosophy, which helps to understand what is so pressing. Biophilosophy is not a philosophy of life that deals with essences—like the structure of the genetic code and its categorizations—a
representational theory of life; rather, biophilosophy focuses on that which transforms life—the focus is on the multiplicity of relations—the network of relations that take the living outside itself, a diagram that is extrinsic as opposed to intrinsic characteristics of a form of life.

The philosophy of biology is trapped in a dichotomy between nature and culture or human and nonhuman or human and inhuman (AI, biobots). Biophilosophy tries to overcome this dualism by decentering the agency of the human subject, a non-anthropocentric ontology and ethics that considers the human as necessarily enmeshed in a multiplicity of relations with human and nonhuman and inhuman (Artificial Intelligence) others. Relational multiplicity is not the same as ‘many’ (like the one and the many) but in terms of a combination—a proliferating number that differs. Gilles Deleuze would call this the connective ‘logic of the and + and + and.’ This is a dynamic and agentic account of matter, and a refusal of human exceptionalism (i.e., placing humans foremost in a world only for-us—only for our species).

Thacker draws on the philosophies of Gilles Deleuze, Félix Guattari, and Gilbert Simondon. Their theories underlie BioArt developments. I end this chapter by stating that artistic research practice (like a/r/tography, for example, that dominates a large part of art|education) is much too caught by the major practices of post-humanism based on a world-for-us, supporting an anthropocentrism and speciesism, two developments, which, while related, are not synonymous. Anthropocentrism focuses on the dominion of Man, as in Kac’s Genesis sentence. Speciesism refers to an exclusion to all those who do not belong to a species. One can substitute ‘human’ for species to show its effects as many are excluded historically from being human (slaves, women, the colonized, and so on). Given the state of the ecological crisis as presented by the Anthropocene era, what some have called a ‘postbiological condition’ of a new Earth, which is the convergence of nanotechnology, biotechnology, information technology, and cognitive science (NBIC) (Dick 2008; Ćirković 2018). To what degree is this vision caught by the transhumanist fix? It seems imperative that artists and art|educators begin to pay attention to what BioArtists are trying to do; to heighten the awareness that not all life is controllable, and that we must begin to live differently if we are to avoid extinction in the future.

The chapter has focused more on synthetic biology that has forwarded ‘the living’ as carbon based through the technologization of the animated. Biomimesis is such a direction where the biochemical wetware
of the natural organism is abstracted and transformed via technology into various bio-synthetic forms. I see this extrapolation taking place by subjugating the nonhuman. On the other side of the ledger are those artists and engineers who place more on animation of the technological, more in line with the purity of AI as silicon-based entities where art is generated by robotics and the algorithms that make them function. A good example here is Leonel Moura robotic paintings. This development extends itself more into the transhuman realm, raising new forms of animated life. While divisions such as software, wetware, dryware, and hardware are perhaps crude ways to categorize the various forms of animated simulation that are being created, their possible combinations seem endless (like Joe Davis’ Bacterial Radio). In the next chapter, I further make use of the terms nonhuman and inhuman to make these distinctions.

REFERENCES

Catts, O., & Zurr, I. (2007). Semi-living art. In E. Kac (Ed.), Signs of life: Bio art and beyond (pp. 231–248). Cambridge, MA and London, England: MIT Press.

Causey, M. (2001). Stealing from God: The crisis of creation in Societas Raffaello Sanzio’s Genesis and Eduardo Kac’s Genesis. Theatre Research International, 26(2), 199–208.

Causey, M. (2002, March). The ethics and anxiety of being with monsters and machines: Thinking through the transgenic art of Eduardo Kac. Crossings: eJournal of Art and Technology, 2(1). Available: http://crossings.tcd.ie/issues/2.1/Causey/.

Čiriković, M. M. (2018). Post-postbiological evolution? Futures, 99, 28–35.

Dardot, P., & Laval, C. (2019). Common: On revolution in the 21st century. London: Bloomsbury Academic.

Dick, S. (2008). The postbiological universe. Acta Astronautica, 62(8–9), 499–504.

Fasick, F. A. (1994). On the ‘invention’ of adolescence. The Journal of Early Adolescence, 14(1), 6–23.

Ginsberg, D. A. C., Schyfter, J., Schyfter, P., Efick, A., & Endy, D. (2014). Synthetic aesthetics: Investigating synthetic biology’s designs on nature. London, England and Cambridge, MA: The MIT Press.

Guattari, F. (2009). Postmodern deadlock and post-media transition. In C. Wiener & E. Wittman (Trans.), Soft subversions: Texts and interviews 1977–1985 (pp. 291–300). Los Angeles, CA: Semiotext(e).

Hayles, K. N. (2012). Digital media and contemporary technogenesis. Chicago: University of Chicago Press.
Hauser, J. (2017). Art between synthetic biology and biohacking: Searching for media adequacy in the epistemological turn. In L. Aceti, P. Thomas, & E. Colless (Eds.), *Leonardo Electronic Almanac: Cloud and Molecular Aesthetics, 22*(1), 128–136.

Hendersen, L. D. (2013). *The fourth dimension and non-Euclidean geometry in modern art* (Revised edition). Cambridge, MA: MIT Press.

Jeremijenko, N. (2007). OneTree. In E. Kac (Ed.), *Signs of life: Bio art and beyond* (pp. 301–302). Cambridge, MA and London: MIT Press.

Jeremijenko, N. (2009, September 17). Amphibious architecture. Available at: http://www.sentientcity.net/exhibit/?p=5.

Jeremijenko, N. (2010). Natalie Jeremijenko: The art of the eco-mindshift. *TedTalk*. Available at: https://www.ted.com/talks/natalie_jeremijenko_the_art_of_the_eco_mindshift/transcript?language=en.

Jeremijenko, N., & Dehlia, H. (2017). Natalie Jeremijenko’s new experimentalism. In R. Grusin (Ed.), *Anthropocene feminism: Between human/non-human valorization and the notion of difference* (pp. 197–219). London and Minneapolis: University of Minnesota Press.

Johnson, E. R. (2017). At the limits of species being: Sensing the Anthropocene. *The South Atlantic Quarterly, 116*(2), 275–292.

Kac, E. (1998, December). Transgenic art. *Leonardo Electronic Almanac, 6*(11). Available: https://test.leoalmanac.org/wp-content/uploads/2012/07/LEA-v6-n11.pdf.

Kac, E. (Ed.). (2007a). *Signs of life: Bio art and beyond*. Cambridge, MA and London, England: MIT Press.

Kac, E. (2007b). Life transformation—Art mutation. In E. Kac (Ed.), *Signs of life: Bio art and beyond* (pp. 163–184). Cambridge, MA and London, England: MIT Press.

Kac, E. (2007c). Art that looks you in the eye: Hybrids, clones, mutants, synthetics, and transgenics. In E. Kac (Ed.), *Signs of life: Bio art and beyond* (pp. 1–28). Cambridge, MA and London, England: MIT Press.

Krauss, R. (2000). *A voyage on the North Sea: Art in the age of the post-medium condition*. London: Thames & Hudson.

Manovich, L. (2000). Post-media aesthetics. Available at: http://manovich.net/index.php/projects/post-media-aesthetics.

Mitchell, R. (2010). *Bioart and the vitality of media*. Seattle and London: University of Washington Press.

Quaranta, D. (2011, January 12). The postmedia perspective. *Rhizome*. Available: http://rhizome.org/editorial/2011/jan/12/the-postmedia-perspective/.

Rifkin, J. (1998). *The biotech century*. New York: Jeremy P. Tarcher/Putnam.

Rosenfeld, H. E., & Sheridan, K. (2014). The maker movement in education. *Harvard Education Review, 84*(4), 495–504.
Savini, M. (2017). Transgenic art: Creativity in the era of genetic engineering. *Technoetic Arts: A Journal of Speculative Research, 15*(2), 163–169.

Stiegler, B. (1998). *Technics and time 1: The fault of Epimetheus* (G. Collins & R. Beardsworth, Trans.). Stanford: Stanford University Press.

TC&A (The Tissue Culture and Art Project). (2000). *The tissue culture and art project*. Available: [http://www.tca.uwa.edu.au/](http://www.tca.uwa.edu.au/).

TC&A (The Tissue Culture and Art Project). (2003). *Disembodied cuisine*. Available: [http://lab.anhb.uwa.edu.au/ tca/disembodied-cuisine/](http://lab.anhb.uwa.edu.au/ tca/disembodied-cuisine/).

TC&A (The Tissue Culture and Art Project). (2004). *Victimless leather*. Available: [https://www.fact.co.uk/artwork/victimless-leather-2004](https://www.fact.co.uk/artwork/victimless-leather-2004).

Thacker, E. (2008). Biophilosophy for the 21st century. In M. Kroker & A. Kroker (Eds.), *Critical digital studies: A reader* (pp. 132–142). Toronto: University of Toronto Press.

Toews, J. E. (1987). Intellectual history after the linguistic turn: The autonomy of meaning and the irreducibility of experience. *The American Historical Review, 92*(4), 879–907.

Weibel, P. (2012, March 19). The post-media condition. *Mute*. Available: [http://www.metamute.org/editorial/lab/post-media-condition](http://www.metamute.org/editorial/lab/post-media-condition).

Weibel, P. (2015, November 2). The seeing tongue: New aspects of neo-Darwinism. *Schloss—Post*. Available: [https://schloss-post.com/the-seeing-tongue/](https://schloss-post.com/the-seeing-tongue/).