

Bio Art: From Genesis to Natural History of the Enigma

Eduardo Kac

ABSTRACT

In 1997 I introduced the concept and the phrase "bio art", originally in relation to my artwork "Time Capsule" (1997).¹ This work approached the problem of wet interfaces and human hosting of digital memory through the implantation of a microchip. The work consisted of a microchip implant, seven sepia-toned photographs, a live television broadcast, a webcast, interactive telerobotic webscanning of the implant, a remote database intervention, and additional display elements, including an X-ray of the implant. While "bio art" is applicable to a large gamut of in-vivo works that employ biological media, made by myself and others, in 1998, I started to employ the more focused term "transgenic art"² to describe a new art form based on the use of genetic engineering to create unique living beings. Art that manipulates or creates life must be pursued with great care, with acknowledgment of the complex issues it raises and, above all, with a commitment to respect, nurture, and love the life created. I have been creating and exhibiting a series of transgenic artworks since 1999. I have also been creating bio art that is not transgenic. The implications of this ongoing body of work have particular aesthetic and social ramifications, crossing several disciplines and providing material for further reflection and dialogue. What follows is an overview of these works, the issues they evoke, and the debates they have elicited.

For almost two decades my work has explored the boundaries between humans, animals, and robots.³ Thus, transgenic art can be seen as a natural development of my previous work. In my telepresence art, developed since 1986, humans coexist with other humans and non-human animals through telerobotic bodies. In my biotelematic art, developed since 1994, biology and networking are no longer co-present but coupled so as to produce a hybrid of the living and the telematic. With transgenic art, developed since 1998, the animate and the technological can no longer be distinguished. The implications of this ongoing work have particular social ramifications, crossing several disciplines and providing material for further reflection and dialogue.

The presence of biotechnology will increasingly change from agricultural and pharmaceutical practices to a larger role in popular culture, just as the perception of the computer changed historically from an industrial device and military weapon to a communication, entertainment,

¹ Patricia Decia, "Artista põe a vida em risco" and "Bioarte," *Folha de São Paulo*, October 10, 1997.

² Eduardo Kac. "Transgenic Art", *Leonardo Electronic Almanac* 6, no. 11 (1998). Republished in *Ars Electronica '99 - Life Science*, ed. Gerfried Stocker and Christine Schopf (Vienna, New York: Springer, 1999), 289-296.

³ See: Eduardo Kac. *Luz & Letra. Ensaaios de arte, literatura e comunicação* [Light & Letter. Essays in art, literature and communication] (Rio de Janeiro: Editora Contra Capa, 2004); Eduardo Kac. *Telepresence and Bio Art -- Networking Humans, Rabbits and Robots* (Ann Arbor: University of Michigan Press, 2005).

and education tool. Terms formerly perceived as “technical”, such as *megabytes* and *ram*, for example, have entered the vernacular. Likewise, jargon that today may seem out of place in ordinary discourse, such as *marker* and *plasmid*, for example, will simply be incorporated into the larger verbal landscape of everyday language. This is made clear by the fact that high school students in the United States already create transgenic bacteria routinely in school labs through affordable kits. The popularization of aspects of technical discourse inevitably brings with it the risk of dissemination of a reductive and instrumental ideological view of the world. Without ever relinquishing its right to formal experimentation and subjective inventiveness, art can, art *should* contribute to the development of alternative views of the world that resist dominant ideologies. In my work I subvert contemporary technologies — not to make detached comments on social change, but to *enact* critical views, to make present in the physical world invented new entities (artworks that include transgenic organisms) which seek to open a new space for both emotional and intellectual aesthetic experience.

I have been employing the phrase "bio art" since 1997, in reference to my own works that involved biological agency (as opposed to biological objecthood), such as "Time Capsule"⁴ and "A-positive"⁵, both presented in 1997. The difference between biological agency and biological objecthood is that the first involves an active principle while the second implies material self-containment. In 1998 I introduced the phrase "transgenic art" in a paper-manifesto with the same title and proposed the creation (and social integration) of a dog expressing green fluorescent protein. This protein is commonly used as a biomarker in genetic research; however, my goal was to use it primarily for its visual properties as a symbolic gesture, a social marker. The initial public response to the paper was curiosity laced with incredulity. The proposal is perfectly viable, but it seemed that few believed that the project could or would be realized. While I struggled to find venues that could assist me in creating the aforementioned project, entitled "GFP K-9", I too realized that canine reproductive technology was not developed enough at the time to enable me to create a dog expressing green fluorescent protein. In the meantime, I started to develop a new transgenic art work, entitled "Genesis", which premiered at Ars Electronica '99.⁶

⁴ Robert Atkins, "State of the (On-Line) Art", *Art in America*, April 1999, 89-95; Carvalho, Mario Cesar, "Artista implanta hoje chip no corpo," *Folha de São Paulo, Cotidiano*, 11 November 1997, p. 3; "Art at the Biological Frontier," *Reframing Consciousness: Art, Mind and Technology*, ed. Roy Ascott (Exeter: Intellect, 1999), 90-94.; Arlindo Machado, "A Microchip inside the Body," *Performance Research* 4, no. 2, ("On Line" special issue, London, 1999), 8-12.; Christiane Paul, "Time Capsule," *Intelligent Agent* 2, no. 2, (1998), 4-13.; Julia Scheeres, "New Body Art: Chip Implants," *Wired News*, March 11, 2002.; Steve Tomasula, "Time Capsule: Self-Capsule," *CIRCA* [Ireland], no. 89 (Autumn 1999), 23-25.

⁵ Gisele Beiguelman, "Artista discute o pós-humano," *Folha de São Paulo*, October 10, 1997; Eduardo Kac, "A-positive," in *ISEA '97 -- The Eighth International Symposium on Electronic Art*, September 22 -27, 1997 (Chicago: The School of the Art Institute of Chicago, 1997), p. 62; Eduardo Kac, "A-positive: Art at the Biobotic Frontier," Flyer distributed on the occasion of ISEA '97; Eduardo Kac, "Art at the Biologic Frontier," in *Reframing Consciousness*, ed. Roy Ascott (Exeter: Intellect, 1999), 90-94; Arlindo Machado, "Expanded Bodies and Minds," in *Eduardo Kac: Teleporting An Unkown State*, ed. Peter Tomaz Dobrila and Aleksandra Kostic (Maribor, Slovenia: KIBLA, 1998), 39-63; Matthew Mirapaul, "An Electronic Artist and His Body of Work," *The New York Times*, October 02, 1997; Simone Osthoff, "From Stable Object to Participating Subject: content, meaning, and social context at ISEA97," *New Art Examiner* (February 1998), 18-23.

⁶ Kac, E. "Genesis", *Ars Electronica '99 - Life Science*, ed. Gerfried Stocker and Christine Schopf (Vienna, New York: Springer, 1999), 310-313. Also: <<http://www.ekac.org/geninfo.html>>. "Genesis" was carried out with

GENESIS

Genesis is a transgenic artwork that explores the intricate relationship between biology, belief systems, information technology, dialogical interaction, ethics, and the Internet. The key element of the work is an "artist's gene", a synthetic gene that was created by translating a sentence from the biblical book of Genesis into Morse Code, and converting the Morse Code into DNA base pairs according to a conversion principle I specially developed for this work. The sentence reads: "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." It was chosen for what it implies about the dubious notion--divinely sanctioned--of humanity's supremacy over nature. Morse code was chosen because, as the first example of the use of radiotelegraphy, it represents the dawn of the information age--the genesis of global communication. The Genesis gene was incorporated into bacteria, which were shown in the gallery. Participants on the Web could turn on an ultraviolet light in the gallery, causing real, biological mutations in the bacteria. This changed the biblical sentence in the bacteria. After the show, the DNA of the bacteria was translated back into Morse code, and then back into English. The mutation that took place in the DNA had changed the original sentence from the Bible. The mutated sentence was posted on the Genesis web site. In the context of the work, the ability to change the sentence is a symbolic gesture: it means that we do not accept its meaning in the form we inherited it, and that new meanings emerge as we seek to change it.

While presenting Genesis, I also gave a public lecture in the context of the symposium "Life Science", presented by Ars Electronica '99. My lecture focused on the "GFP K-9" proposal. To contextualize my presentation, I reviewed the long history of human-dog domestication and partnership, and pointed out the direct and strong human influence on the evolution of the dog up to the present day. Emphasizing that there are no packs of Poodles and Chihuahuas running in the wild, and that the creation of the dog out of the wolf was a technology -- a fact that we seemed to have lost conscience of -- I proceeded to point out the complex relationship between dogs and humans throughout their long history together, going back at least fourteen thousand years according to archeological records. While some showed support and appreciation for the work, others reacted against the project and voiced their position. The stage was set for a very productive dialogue, which was one of my original intentions. As I see it, the debate must go beyond official policy-making and academic research to encompass the general public, including artists. "GFP K-9" was discussed in art magazines and books and science journals. Daily papers and general magazines also discussed the work in progress. While specialized publications showed greater appreciation for "GFP K-9", the response in the general media covered the whole gamut, from forthright rejection to consideration of multiple implications to unmistakable support. The shock generated by the proposal curiously caused one critic to declare "the end of art"⁷. As I see it, there's no reason to see the beginning of a new art as the end of anything.

the assistance of Dr. Charles Strom, formerly Director of Medical Genetics, Illinois Masonic Medical Center, Chicago. Dr. Strom is now Medical Director, Biochemical and Molecular Genetics Laboratories Nichols Institute / Quest Diagnostics, San Juan Capistrano, CA. Original DNA music for Genesis was composed by Peter Gena.

⁷ Charles Mudede, "The End of Art", *The Stranger* [Seattle] 9, no. 15, (Dec. 30, 1999 - Jan. 05, 2000).

GFP BUNNY

This pattern of response repeated itself, at a truly global scale, when I announced in 2000 the realization of my second transgenic work. Entitled "GFP Bunny", the work comprises the creation of a green fluorescent rabbit ("Alba"), the public dialogue generated by the project, and the social integration of the rabbit. This work was realized with the assistance of Louis Bec and Louis-Marie Houdebine. Louis Bec worked as the producer, coordinating the activities in France. Bec and I met at Ars Electronica (September 1999) and soon afterwards he contacted Houdebine on my behalf, for the first time, to propose the project. Months later, in 2000, Alba was born, a gentle and healthy rabbit. As I stated in my paper entitled "GFP Bunny"⁸, "transgenic art is a new art form based on the use of genetic engineering to create unique living beings. This must be done with great care, with acknowledgment of the complex issues thus raised and, above all, with a commitment to respect, nurture, and love the life thus created."

"GFP Bunny" attracted local media in the south of France in June 2000 when the former director of the French institute where Alba was born used his authority to overrule the scientists who worked on the project and refused to let Alba go to Avignon and then come to my family in Chicago. The arbitrary decision was made privately by one individual (the former director of the French institute where Alba was born). He never explained his reason for the refusal, so it remains unknown to this day. Bec and I denounced this censorship through the Internet and through interviews to the press.⁹ If the objective was to silence the media, the result backfired. "GFP Bunny" became a global media scandal after a front-page article appeared in the *Boston Globe*,¹⁰ sharing headlines with articles about the 2000 Olympics and US presidential debates. Articles about Alba were published in all major countries, with wire services further spreading the news worldwide.¹¹ Alba was also on the cover of *Le Monde*, *San Francisco Chronicle* and *L'Espresso*, among others. *Der Spiegel* and *Chicago Tribune* dedicated full pages to "GFP Bunny". She also appeared on the front page of the Arts section of the *New York Times*.

⁸ Eduardo Kac, "GFP Bunny," in *Eduardo Kac: Telepresence, Biotelematics, and Transgenic Art*, ed. Peter Tomaz Dobrila and Aleksandra Kostic (Maribor, Slovenia: KIBLA, 2000), 101-131. Also: <<http://www.ekac.org/gfpbunny.html>>.

⁹ I had proposed to live for one week with Alba in the Grenier à Sel, in Avignon, where Louis Bec directed the art festival "Avignon Numérique". In an email broadcast in Europe on June 16, 2000, Bec wrote: "Contre notre volonté, le programme concernant «Artransgénique», qui devait se dérouler du 19 au 25 juin, se trouve modifié. Une décision injustifiable nous prive de la présence de Bunny GFP, le lapin transgénique fluorescent que nous comptions présenter aux Avignonnais et à l'ensemble des personnes intéressées par les évolutions actuelles des pratiques artistiques. Malgré cette censure déguisée, l'artiste Eduardo Kac, auteur de ce projet, sera parmi nous et présentera sa démarche ainsi que l'ensemble de ses travaux. Un débat public permettra d'ouvrir une large réflexion sur les transformations du vivant opérées par les biotechnologies, tant dans les domaines artistiques et juridiques, qu'éthiques et économiques. Nous nous élevons de toute évidence contre le fait qu'il soit interdit aux citoyens d'avoir accès aux développements scientifiques et culturels qui les concernent si directement."

¹⁰ Gareth Cross. "Cross hare: hop and glow", *Boston Globe*, September 17, 2000, A01. The article states: "Kac and Alba remain apart while Kac tries to persuade the French government laboratory, called the National Institute of Agronomic Research, to grant him custody of the bunny. The scientist who created her for Kac, Louis-Marie Houdebine, said he doesn't know when, or if, Alba will be allowed to join Kac, but said that she is healthy, and even noted that she has a "particularly mellow and sweet disposition."

¹¹ For a bibliography on transgenic art, see: <<http://www.ekac.org/transartbiblio.html>>.

Broadcasts by ABC TV, BBC Radio, and Radio France also took the Alba story to the whole planet. The relentless response to "GFP Bunny" has been equally intense and fascinating, with fruitful debate and both strong opposition and support. From October 15, 2000 to December 02, 2004, the "Alba Guestbook" collected general opinions about the work and expressions of support to bring Alba home.¹² Through lectures and symposia, Internet postings and email correspondence, the debate intensified and became richer, more subtle and nuanced, as I had hoped. The response to "GFP Bunny" constitutes extremely rich material, which I hope to revisit in the near future.

As part of my intercontinental custody battle to obtain Alba's release, between December 3 and December 13, 2000, I staged a public campaign in Paris, which included lectures, broadcasts, public and private meetings, and the public placement of a series of seven posters. I placed individual posters in several neighborhoods, including: Le Marais, Quartier Latin, Saint Germain, Champs de Mars, Bastille, Montparnasse, and Montmartre. The posters reflect some of the readings afforded by "GFP Bunny". They show the same image of Alba and I together, each topped by a different French word: Art, Médias, Science, Éthique, Religion, Nature, Famille. Between December 3 and December 13, 2000, parallel to radio (Radio France and Radio France Internationale), print (Le Monde, Libération, Transfert, Ça M'intéresse, Nova), and television (Canal+, Paris Première) interviews and debates, I posted these images on the streets in an effort to intervene in the context of French public opinion and gather support for my cause to bring Alba home. I also engaged the public directly through a series of lectures (Sorbonne, École Normale Superior, École Superior des Beaux Arts, Forum des Images) and through face-to-face conversations on the street sparked by the public's interest. In total, I reached approximately 1.5 million people (about half of the population of Paris). This was an important step, as it allowed me to address the Parisian public directly. In 2001 I created "The Alba Flag", a white flag with the green rabbit silhouette, and started to fly it in front of my Chicago-area house. The flag not only signals publicly the home of the green bunny, but most importantly stands as a social marker, a beacon of her absence.

Continuing my efforts to raise awareness about Alba's plight and to obtain her freedom, in 2002 I presented a solo exhibition entitled "Free Alba!"¹³ at Julia Friedman Gallery, in Chicago (May 3 - June 15, 2002). "Free Alba!" included a large body of new work comprised of large-scale color photographs, drawings, prints, Alba flags, and Alba t-shirts. Seen together for the first time were the posters from my public interventions in Paris (2000), an Alba flag flying outside the Gallery (2001), photographs that reclaim green bunny narratives circulated by global media (2001-02), drawings that reflect on our closeness to the "animal other" (2001-2002) and Alba t-shirts that extend Alba's cause beyond gallery's walls (2002). Through the leitmotif of the green bunny, this exhibition explored the poetics of life and evolution. The story of "GFP Bunny" was adapted and customized by news organizations worldwide, often generating new narratives that, both intentionally and unintentionally, reinstated or overlooked the facts. My "Free Alba!" exhibition featured photographs in which I reappropriated and recontextualized this vast coverage, exhibiting the productive tension that is generated when contemporary art enters the realm of daily news. The photographs in this series dramatize the fact that the reception of GFP Bunny

¹² http://www.ekac.org/bunnybook.2000_2004.html

¹³ Lisa Stein, "New Kac Show Takes a Look at Ethics, Rabbit," *Chicago Tribune*, May 10, 2002, 21.

was complex, taking place across cultures and in diverse locations. With her passing, I will continue to create new works through which I celebrate her life.

THE EIGHTH DAY, A TRANSGENIC ARTWORK

While in "GFP Bunny" I created a new mammal, in the transgenic work that followed, entitled "The Eighth Day", I investigated the new ecology of fluorescent creatures that is evolving worldwide. It was shown from October 25 to November 2, 2001 at the Institute for Studies in the Arts, Arizona State University, Tempe.¹⁴ While fluorescent creatures are being developed in isolation in laboratories, seen collectively in this work for the first time they form the nucleus of a new and emerging synthetic bioluminescent ecosystem. The piece brings together living transgenic life forms and a biological robot (biobot) in an environment enclosed under a clear Plexiglas dome, thus making visible what it would be like if these creatures would in fact coexist in the world at large.

As the viewer walks into the gallery, she first sees a blue-glowing semisphere against a dark background. This semisphere is the 4-foot dome, aglow with its internal blue light. She also hears the recurring sounds of water washing ashore. This evokes the image of the Earth as seen from space. The water sounds both function as a metaphor for life on Earth (reinforced by the spherical blue image) and resonate with the video of moving water projected on the floor. In order to see "The Eighth Day" the viewer is invited to "walk on water".

In the gallery, visitors are able to see the terrarium with transgenic creatures both from inside and outside the dome. As they stand outside the dome looking in, someone online sees the space from the perspective of the biobot looking out, perceiving the transgenic environment as well as faces or bodies of local viewers. An online computer in the gallery also gives local visitors an exact sense of what the experience is like remotely on the Internet.

Local viewers may temporarily believe that their gaze is the only human gaze contemplating the organisms in the dome. However, once they navigate the Web interface they realize that remote viewers can also experience the environment from a bird's eye point of view, looking down through a camera mounted above the dome. They can pan, tilt, and zoom, seeing humans, mice, plants, fish and the biobot up close. Thus, from the point of view of the online participant, local viewers become part of the ecology of living creatures featured in the work, as if enclosed in a websphere.

"The Eighth Day" presents an expansion of biodiversity beyond wildtype life forms. As a self-contained artificial ecology it resonates with the words in the title, which add one day to the period of creation of the world as narrated in the Judeo-Christian scriptures. All of the transgenic creatures in "The Eighth Day" are created with the same gene I used previously in "GFP Bunny"

¹⁴ I developed "The Eighth Day" through a two-year residency at the Institute of Studies in the Arts, Arizona State University, Tempe. The exhibition dates: October 25 to November 2, 2001. Exhibition location: Computer Commons Gallery, Arizona State University, Tempe (with the support of the Institute of Studies in the Arts). Documentation can be found at: <<http://www.ekac.org/8thday.html>>. See: *The Eighth Day: The Transgenic Art of Eduardo Kac*, ed. Sheilah Britton and Dan Collins (New York: ASU / Distributed by DAP, 2003).

to create "Alba", a gene that allows all creatures to glow green under harmless blue light.¹⁵ The transgenic creatures in "The Eighth Day" are GFP plants, GFP amoeba, GFP fish, and GFP mice. Selective breeding and mutation are two key evolutionary forces. "The Eighth Day" literally raises the question of transgenic evolution, since all organisms in the piece are mutations of their respective wildtype species and all were selected and bred for their GFP mutations.

"The Eighth Day" also includes a biological robot. A biobot is a robot with an active biological element within its body that is responsible for aspects of its behavior. The biobot created for "The Eighth Day" has a colony of GFP amoeba called *Dyctiostelium discoideum* as its "brain cells". These "brain cells" form a network within a bioreactor that constitutes the "brain structure" of the biobot. When amoebas divide, the biobot exhibits dynamic behavior inside the enclosed environment. Changes in the amoebal colony (the "brain cells") of the biobot are monitored by it, and cause it to move about, throughout the exhibition. The biobot also functions as the avatar of Web participants inside the environment. Independent of the ascent and descent of the biobot, Web participants are able to control its audiovisual system with a pan-tilt actuator. The autonomous motion, which often causes the biobot to lean forward in different directions, provides Web participants with new perspectives of the environment.

The biobot's "amoebal brain" is visible through the transparent bioreactor body. In the gallery, visitors are able to see the terrarium with transgenic creatures from outside and inside the dome, as a computer in the gallery gives local visitors an exact sense of what the experience is like on the Internet. By enabling participants to experience the environment inside the dome from the point of view of the biobot, "The Eighth Day" creates a context in which participants can reflect on the meaning of a transgenic ecology from a first-person perspective.

MOVE 36

In "The Eighth Day", the biobot embodies a biological component to materialize a hybrid of the living and the nonliving. Another way in which society has experienced the future abilities of machines was through Deep Blue, a computer that beat Chess world champion Gary Kasparov in 1997.¹⁶ My transgenic artwork "Move 36" makes reference to Deep Blue's dramatic winning move. The competition between Kasparov and Deep Blue can be characterized as a match between the greatest chess player who ever lived against the greatest chess player who never lived. The work -- presented for the first time at the Exploratorium, in San Francisco, from February 26 to May 31, 2004 -- sheds light on the limits of the human mind and the increasing capabilities developed by computers and robots, inanimate beings whose actions often acquire a force comparable to subjective human agency.

¹⁵ In 2008, the scientists who developed GFP into a harmless and useful scientific tool received the Nobel Prize in Chemistry. One of the recipient scientists featured "GFP Bunny" in his Nobel lecture, also published in the 2008 Nobel Prize book. See: Chalfie, Martin. "GFP: Lighting Up Life", in: *The Nobel Prizes 2008* (Stockholm: Nobel Foundation, 2009), p. 162.

¹⁶ See: Elena Giulia Rossi. *Eduardo Kac: Move 36* (Paris: Filigranes Éditions, 2005).

According to Kasparov, Deep Blue's quintessential moment in Game Two came at Move 36. Rather than making a move that was expected by viewers and commentators alike—a sound move that would have afforded immediate gratification—it made a move that was subtle and conceptual and, in the long run, better. Kasparov could not believe that a machine had made such a keen move. The game, in his mind, was lost.

The work presents a Chessboard made of earth (dark squares) and white sand (light squares) in the middle of the room. There are no chess pieces on the board. Positioned exactly where Deep Blue made its Move 36 is a plant whose genome incorporates a new gene that I created specifically for this work. The gene uses ASCII (the universal computer code for representing binary numbers as Roman characters, on- and off-line) to translate to the four bases of genetics Descartes' statement: "Cogito ergo sum" (I think therefore I am).

Through genetic modification, the leaves of the plants grow multiple plantlets. In the wild these leaves would be smooth. The "Cartesian gene" was coupled with a gene for the expression of the plantlets, so that the public can easily see with the naked eye that the "Cartesian gene" is expressed precisely where the plantlets grow.

The "Cartesian gene" was produced according to a new code I created especially for the work. In 8-bit ASCII, the letter C, for example, is: 01000011. Thus, the gene is created by the following association between genetic bases and binary digits:

A = 00

C = 01

G = 10

T = 11

The result is the following gene with 52 bases:

CAATCATTCAGCCCCACATTCACCCCAGCACTCATTCCATCCCCCATC

The creation of this gene is a critical and ironic gesture, since Descartes considered the human mind a "ghost in the machine" (for him the body was a "machine"). His rationalist philosophy gave new impetus both to the mind-body split (Cartesian Dualism) and to the mathematical foundations of current computer technology.

The presence of this "Cartesian gene" in the plant, rooted precisely where the human lost to the machine, reveals the tenuous border between humanity, inanimate objects endowed with life-like qualities, and living organisms that encode digital information. A single focused light shines in a delicate luminous cone over the plant. Silent square video projections on two opposing walls contextualize the work, evoking two chess opponents in absentia. Each video projection is composed of a grid of small squares, resembling a chessboard. Each square shows short animated loops cycling at different intervals, thus creating a complex and carefully

choreographed thread of movements. The viewer's cognitive engagement with the multiple visual possibilities presented on both projected boards subtly emulates the mapping of multiple paths in a chess match.

This work explores the poetics of real life and evolution; it is a game for phantasmic players, a philosophical statement uttered by a plant. "Move 36" gives continuity to my ongoing interventions at the boundaries between the living (human, non-human animals) and the non-living (machines, networks). Checkmating traditional notions, nature is revealed as an arena for the production of ideological conflict, and the physical sciences as a locus for the creation of science fictions.

SPECIMEN OF SECRECY ABOUT MARVELOUS DISCOVERIES

Expanding on ecological and evolutionary issues I previously explored in transgenic works such as "The Eighth Day", my "Specimen of Secrecy about Marvelous Discoveries" is a series of works comprised of what I call "biotopes", that is, living pieces that change during the exhibition in response to internal metabolism and environmental conditions, including temperature, relative humidity, airflow, and light levels in the exhibition space.¹⁷ Each of my biotopes is literally a self-sustaining ecology comprised of thousands of very small living beings in a medium of earth, water, and other materials. I orchestrate the metabolism of this diverse microbial life in order to produce the constantly evolving living works. In embracing the mutability of unpredictable circumstances and evolving in response to human care and environmental conditions, the biotopes further develop dialogical principles that have been central to my work for over two decades.

The biotopes are a discrete ecology because within their world the microorganisms interact with and support each other (that is, the activities of one organism enable another to grow, and vice-versa). However, they are not entirely secluded from the outside world: the aerobic organisms within the biotope absorb oxygen from outside (while the anaerobic ones comfortably migrate to regions where air cannot reach).

A complex set of relationships emerge as the work unfolds, bringing together the internal dialogical interactions among the microorganisms in the biotope and the interaction of the biotope as a discrete unit with the external world.

The biotope is what I call a "nomadic ecology", that is, an ecological system that interacts with its surroundings as it travels around the world. Every time a biotope migrates from one location to another, the very act of transporting it causes an unpredictable redistribution of the microorganisms inside it (due to the constant physical agitation inherent in the course of a trip). Once in place, the biotope self-regulates with internal migrations, metabolic exchanges, and material settling. Extended presence in a single location might yield a different behavior, possibly resulting in regions of settlement and color concentration.

¹⁷ "Specimen of Secrecy About Marvelous Discoveries" premiered at the Singapore Biennale (4 September - 12 November 2006).

The biotope is affected by several factors, including the very presence of viewers, which can increase the temperature in the room (warm bodies) and release other microorganisms into the air (breathing, sneezing).

I consider the exhibition opening as the birth of a given biotope. Once an exhibition begins, I allow the microorganisms in suspended animation to become active again. From that point on I no longer intervene. The work becomes progressively different, changing every day, every week, every month.

When the viewer looks at a biotope, she sees what could be described as an "image". However, since this "image" is always evolving into its next transformative state, the perceived "stillness" is more a consequence of the conditions of observation (limits of the human perception, ephemeral presence of the viewer in the gallery) than an internal material property of the biotope. Viewers looking at the biotope another day will see a different "image". Given the cyclical nature of this "image", each "image" seen at a given time is but a moment in the evolution of the work, an ephemeral snapshot of the biotope metabolic state, a scopic interface for human intimacy.

Each of my "biotopes" explores what I call "biological time", which is time manifested throughout the life cycle of a being itself, in vivo (contrary to, say, the frozen time of painting or photography, the montaged time of film or video, or the real time of a telecommunications event).

This open process continuously transforms the image and may, depending on factors such as lighting conditions and exhibition length, result in its effacement — until the cycle begins again.

The biotope's cycle begins when I produce the self-contained body by integrating microorganisms and nutrient-rich media. In the next step, I control the amount of energy the microorganisms receive in order to keep some of them active and others in suspended animation. This results in what the viewer may momentarily perceive as a still image. However, even if the image seems "still," the work is constantly evolving and is never physically the same. Only time-lapse video can reveal the transformation undergone by a given biotope in the course of its slow change and evolution.

To only think of a biotope in terms of microscopic living beings is extremely limiting. While it is also possible to describe a human being in terms of cells, a person is much more than an agglomerate of cells. A person is a whole, not the sum of parts. We shall not confuse our ability to describe a living entity in a given manner (e.g., as an object composed of discrete parts) with the phenomenological consideration of what it is like to be that entity, for that entity. The biotope is a whole. Its presence and overall behavior is that of a new entity that is at once an artwork and a new living being. It is with this bioambiguity that it manifests itself. It is as a whole that the biotope behaves and seeks to satisfy its needs. The biotope asks for light and, occasionally, water. In this sense, it is an artwork that asks for the participation of the viewer in the form of personal care. Like a pet, it will keep company and will produce more colors in response to the care it receives. Like a plant, it will respond to light. Like a machine, it is programmed to

function according to a specific feedback principle (e.g., expose it to more heat and it will grow more). Like an object, it can be boxed and transported. Like an animal with an exoskeleton, it is multicellular, has fixed bodily structure and is singular. What is the biotope? It is its plural ontological condition that makes it unique.

NATURAL HISTORY OF THE ENIGMA

The intimacy and personal interaction that characterize our relationship with the biotopes are also present, but take a different turn in "Natural History of the Enigma". This series is centered on what I call a plantimal, a new life form I created and named Edunia, a genetically-engineered flower that is a hybrid of myself and a petunia. The Edunia expresses my DNA exclusively in its red veins.

Developed between 2003 and 2008, and first exhibited from April 17 to June 21, 2009 at the Weisman Art Museum,¹⁸ in Minneapolis, "Natural History of the Enigma" also encompasses a large-scale public sculpture, a print suite, photographs, and other works.

The new flower is a Petunia strain that I invented and produced through molecular biology. It is not found in nature. The Edunia has red veins on light pink petals and a gene of mine is expressed on every cell of its red veins¹⁹, i.e., my gene produces a protein in the veins only.²⁰ The gene was isolated and sequenced from my blood. The petal pink background, against which the red veins stand out, is evocative of my own pinkish white skin tone that is due precisely to the blood that flows beneath it. The result of this molecular manipulation is a bloom that creates the living image of human blood rushing through the veins of a flower.

The gene I selected is responsible for the identification of foreign bodies. In this work, it is precisely that which identifies and rejects the other that I integrate into the other, thus creating a new kind of self that is partially flower and partially human.

"Natural History of the Enigma" uses the redness of blood and the redness of the plant's veins as a marker of our shared heritage in the wider spectrum of life. By combining human and plant

¹⁸ The exhibition was comprised of the actual Edunias, the complete "Edunia Seed Pack" set of six lithographs, and a limited edition of Edunia seed packs with actual Edunia seeds.

¹⁹ The gene of mine I used is an IgG fragment. Immunoglobulin G (IgG) is a kind of protein that function as an antibody. IgG is found in blood and other bodily fluids, and is used by the immune system to identify and neutralize foreign antigens. An antigen is a toxin or other foreign substance that provokes an immune response in the body, such as viruses, bacteria and allergens). In "Natural History of the Enigma", the fusion protein, produced exclusively in the red veins, is a fusion of my IgG fragment with GUS (an enzyme that allowed me to confirm the vascular expression of the gene).

²⁰ In actuality, genes do not "produce" proteins. As Richard Lewontin clearly explains: "A DNA sequence does not specify protein, but only the amino acid sequence. The protein is one of a number of minimum free-energy foldings of the same amino acid chain, and the cellular milieu together with the translation process influences which of these foldings occurs." See: R. C. Lewontin, "In the Beginning Was the Word," *Science* 291, no. 16 (February 2001), 1264.

DNA in a new flower, in a visually dramatic way (red expression of human DNA in the flower veins), I bring forth the realization of the contiguity of life between different species.

This work seeks to instill in the public a sense of wonder about this most amazing of phenomena we call “life”. The general public may have no difficulty in considering how close we truly are to apes and other non-human animals, particularly those with which it is possible to communicate directly, such as cats and dogs. However, the thought that we are also close to other life forms, including flora, will strike most as surprising.

While in the history of art one finds imaginative associations between anthropomorphic and botanical forms (as in the work of Archimboldo, for example), this parallel (between humans and plants) also belongs to the history of philosophy and to contemporary science. Advancing notions first articulated by Descartes, Julien Offray de La Mettrie (1709-1751) already proposed in his book *L'Homme Plante* [Man a Plant] (1748) that “the singular analogy between the plant and animal kingdoms has led me to the discovery that the principal parts of men and plants are the same.” The preliminary sequencing of the human genome and that of a plant from the mustard family (*Arabidopsis thaliana*, in the journal *Nature*, December 14, 2000) have extended the artist's and the philosopher's analogies beyond their wildest dreams, into the deepest recesses of the human and plant cells. Both have revealed homologies between human and plant genetic sequences.

Thus, the key gesture of "Natural History of the Enigma" takes place at the molecular level. It is at once a physical realization (i.e., a new life created by an artist, *tout court*) and a symbolic gesture (i.e., ideas and emotions are evoked by the very existence of the flower).

I had a sample of my blood drawn and subsequently isolated a genetic sequence that is part of my immune system—the system that distinguishes self from non-self, i.e., protects against foreign molecules, disease, invaders – anything that is not me. To be more precise, I isolated a protein-coding sequence of my DNA from my Immunoglobulin (IgG) light chain (variable region).²¹

To create a *Petunia* with red veins in which my blood gene is expressed, I made a chimeric gene composed of my own DNA and a promoter to guide the red expression only in the flower's vascular system, not in the petals or the rest of the flower. In order to make my blood-derived DNA express only in the red veins of the *Petunia*, I used Professor Neil Olszewski's CoYMV (Commelina Yellow Mottle Virus) Promoter, which drives gene expression exclusively in plant veins. Professor Olszewski is in the Department of Plant Biology at the University of Minnesota, St. Paul, MN.²²

²¹ For her assistance in drawing my blood, isolating my IgG and cloning it, I owe a debt of gratitude to Bonita L. Baskin, who was, at the time I carried out this work, the CEO of Apptec Laboratory Services, St. Paul, MN. The blood was drawn for "Natural History of the Enigma" on May 13th, 2004 in the premises of Apptec Laboratory Services.

²² With the assistance of Professor Neil Olszewski, I obtained positive confirmation that my IgG protein was produced only in the edunia veins by detecting the activity of the enzyme GUS (beta glucuronidase), which is

My IgG DNA is integrated into the chromosome of the Edunia. This means that every time that the Edunia is propagated through seeds my gene is present in the new flowers.

The sculpture that is part of "Natural History of the Enigma" is a three-dimensional fiberglass and metal form measuring 14'4" (height) x 20'4" (length) x 8' 5" (width.) It contrasts the minute scale of the molecular procedure with the larger-than-life structure. Likewise, the work pairs the ephemeral quality of the living organism with the permanence of the large sculpture. The²³ sculpture is directly connected to the flower because its form is an enlargement of unique forms found inside this invented flower. In other words, the sculpture is derived from the molecular procedure employed to create the flower.²⁴ In its hybridity, the sculpture reveals the proximity of our next of kin in the kingdom *Plantae*.

I used 3D imaging and rapid-prototyping to visualize this fusion protein as a tangible form. I created the visual choreography of the sculpture based on the flower's molecular uniqueness. The sculpture was created with a vocabulary of organic twists and turns, helices, sheets and other three-dimensional features common to all life. The sculpture is blood red, in connection to the starting point of the work (my blood) and the veinal coloration of the Edunia.

In anticipation of a future in which Edunias can be distributed socially and planted everywhere, I created a set of six lithographs entitled "Edunia Seed Packs". Visually resonant as they are with the flower and the work's theme, these images are meant to be used in the actual seed packs to be produced in the future. In my exhibition at the Weisman Art Museum, I exhibited a limited edition of Edunia seed packs containing actual Edunia seeds.

CYPHER

Similar to all of the preceding works discussed here (with the exception of the biotopes), "Cypher" is transgenic. It merges sculpture, artist's book and a DIY transgenic kit. The work measures approximately 13 x 17" and is contained in a stainless steel slipcase. When removed from the case, the kit — itself also made of stainless steel — opens up in two halves, like a book. Inside, the viewer/user finds a portable minilab. The kit contains Petri dishes, agar, nutrients, streaking loops, pipettes, test tubes, synthetic DNA (encoding in its genetic sequence a poem I wrote specifically for this artwork), and a booklet containing the transformation protocol—each in its respective compartment.

The work literally comes to life when the viewer/reader/user follows the protocol in the booklet and integrates the synthetic DNA into the bacteria (the "transformation"). The bacteria (normally pale) will then glow red, showing through this transgenic visual marker that the

fused to the IgG sequence. The detection was achieved through a staining technique. This was further confirmed through PCR.

²⁴ The sculpture's form is an invented protein composed of human and plant parts. The human part is a fragment of my Immunoglobulin (IgG) light chain (variable region). The plant component is from the Petunia's ANTHOCYANIN1 (AN1), responsible for red pigmentation in the flower. More precisely, AN1 is a transcription factor that controls genes encoding the enzymes that produce the red pigments.

artwork is now alive. In bacterial division, two identical clone cells are always produced. After the transformation, the poem will be fully integrated into the bacteria's cellular machinery and therefore will be present in each newly reproduced bacterium.

"Cypher" visually hybridizes sculpture and artist's book : a three-dimensional metal object (with a velvety internal coating, finished by hand using industrial techniques and complemented with glass objects) is initially handled like a book, only to reveal itself as a nomadic laboratory. The key poetic gesture in "Cypher" is to place in the hands of the viewer the decision and the power to literally give life to the artwork.

The synthetic DNA in "Cypher" encodes in its genetic sequence a poem I wrote specifically for this artwork. The code replaces alphabetic letters included in the poem with short DNA sequences of two or three bases. The poem "Cypher" is composed with a high statistical incidence of the four letters that represent the four genetic bases Adenine, Cytosine, Guanine, and Thymine (i.e., A, C, G and T). The set of remaining letters is formed by four consonants and two vowels: these additional six letters were carefully selected to form a "code within the code" that serves as semantic counterpoint to the apparently enigmatic meaning of the poem. The result of this process is that poem and code complement each other in such a way that the code is absolutely integral to the poem. Both are included in the booklet present in the kit, thus enabling the viewer to discover this relationship while following the protocol to give life to the poem. The title manifests an anagrammatic relationship between sign and referent that is, itself, also part of the work.

"Cypher" is an artwork that presents itself as an invitation; it is a call to engage with a set of procedures that merge art and poetry, biological life and technology, reading/viewing and kinesthetic participation. This sculptural object's relationship to the book is enhanced by the fact that the title of the work is engraved on the spine of the slipcase and on the "cover" (the front of the kit). The work can go on a bookshelf and be clearly identified. When opened, the viewer discovers a complete transgenic kit. The participant reads the poem by transforming *E. coli* with the provided synthetic DNA. The act of reading is procedural. In following the outlined procedure, the participant creates a new kind of life—one that is at once literal and poetic.

CONCLUSION

The tangible and symbolic coexistence of the human and the transgenic, which I have developed in several of my works discussed above, shows that humans and other species are evolving in new ways. It dramatizes the need to develop new models with which to understand this change, and calls for the interrogation of difference, taking into account clones, transgenics and chimeras.

Although not all of the works discussed in this essay are transgenic, all of my bio art, from "Genesis" to "Cypher", explores our perceptions of what is "natural" and what is "monstrous". The common belief that transgenics are unnatural is incorrect; it is important to understand that the process of moving genes from one species to another is a part of wild life beyond human

intervention. A common example of this is “agrobacterium”²⁵, which has the ability to transfer DNA into plant cells through the roots and integrate that DNA into the plant chromosome. Even humans have sequences in their genome that came from viruses and bacteria acquired through a long evolutionary history; we have DNA in our bodies from nonhuman organisms, thus, we are ourselves transgenic²⁶. Before deciding that all transgenics are monstrous, humans must look within and come to terms with their own transgenic condition, their own “monstrosity”.

But bio art, rather than commenting on what it means to create life, actually creates life. These works embody the absolute freedom of creation of poetry while simultaneously emerging from the sustained inquiry upon the world brought about through philosophical rigor. They make us question not only who we are as humans, but also what that physical identity means in the context of a wide universe of living beings. Bio art suggests that idealized notions of what is “natural” must be challenged and the human role in the evolutionary history of other species (and vice versa) acknowledged, while at the same time respectfully and humbly marveling at this amazing phenomenon we call “life”.

“Bio Art: From Genesis to Natural History of the Enigma,” in: Grau, Oliver, ed. (with Thomas Veigl). *Imagery in the 21st Century* (Cambridge: MIT Press, 2011), pp. 57-80.

²⁵ This natural ability has made a genetically engineered version of the agrobacterium a favorite tool of molecular biology. See: L. Herrera-Estrella, *Transfer and expression of foreign genes in plants*. PhD thesis. (Laboratory of Genetics, Gent University, Belgium, 1983); P.J.J. Hooykaas and R.A. Shilperoort, “Agrobacterium and plant genetic engineering,” *Plant Molecular Biology* 19 (1992), 15-38; J.R. Zupan and P.C. Zambryski, “Transfer of T-DNA from Agrobacterium to the plant cell,” *Plant Physiology* 107 (1995), 1041-1047.

²⁶ See T. A. Brown, *Genomes* (Oxford, UK : Bios Scientific Publishers, 1999), 138; and David Baltimore, “Our genome unveiled”, *Nature* 409, no. 15 (February 2001), 814-816. In private email correspondence (28 January 2002), and as a follow up to our previous conversation on the topic, Dr. Jens Reich, Division of Genomic Informatics of the Max Delbruck Center in Berlin-Buch, stated: “The explanation for these massive [viral] inserts into our genome (which, incidentally, looks like a garbage bin anyway) is usually that these elements were acquired into germ cells by retrovirus infection and subsequent dispersion over the genome some 10 to 40 millions ago (as we still were early apes).” The HGP also suggests that humans have hundreds of bacterial genes in the genome. See: “Initial sequencing and analysis of the human genome,” *International Human Genome Sequencing Consortium v.* 409, no. 6822 (February 15, 2001), 860. Of the 223 genes coding for proteins that are also present in bacteria and in vertebrates, 113 cases are believed to be confirmed. See p. 903 of the same issue. In the same correspondence mentioned above, Dr. Reich concluded: “It appears that it is not man, but all vertebrates who are transgenic in the sense that they acquired a gene from a microorganism.”