

Bio Art: Proteins, Transgenics, and Biobots

For almost two decades my work has explored the boundaries between humans, animals, and robots¹. 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.

As transgenic art continues to evolve and branch into new propositions, a quick review of the last three years seems useful as an introduction to new developments.

In 1998 I introduced the phrase “transgenic art” in a paper-manifesto with the same title² and proposed the creation (and social integration) of a dog expressing green fluorescent protein. 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 99.³

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 Kac 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 specially developed by the artist 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 in which 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 domes-

tication and partnership, and pointed out the direct and strong human influence on the evolution of the dog up to the present day. While some showed support and appreciation for the work, many 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 include 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



Eduardo Kac, “GFP Bunny—Paris Intervention”,
December 3-13, 2000.

Courtesy Julia Friedman Gallery, Chicago.

the general media covered the whole gamut, from forthright rejection to consideration of multiple implications to unmistakable support.

This pattern of response repeated itself, on 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. As I stated in my paper entitled *GFP Bunny*⁴, “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 contradicted the scientists who worked on the project and refused to let Alba come to my family in Chicago. This arbitrary decision was made privately by one individual in the isolation of his office. He never explained the reason for his refusal, so it remains unknown to this day. 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*⁵. Articles about Alba were published in all major countries, with wire services further spreading the news worldwide⁶. Alba was also on the cover of *Le Monde* and *San Francisco Chronicle*, among others. *Der Spiegel* and *Chicago Tribune* dedicated full pages to *GFP Bunny*. Broadcasts by ABC TV, BBC Radio, and Radio France also took the Alba story to the whole planet. From mid-2000 to mid-2001, the relentless response to *GFP Bunny* has been equally intense and fascinating, with both strong opposition and support. Since October 15, 2000, the “Alba Guestbook” has been collecting general opinions about the work and expressions of support to bring Alba home⁷. Through lectures and symposia, 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 six posters. I placed individual posters in several neighborhoods, including: Le Marais, Quartier Latin, Saint Germain, Champs de Mars, Bastille, Montparnasse, and Montmartre. The



Courtesy Julia Friedman Gallery, Chicago.

Eduardo Kac, Posters from the series "GFP Bunny—Paris Intervention," 2000.

posters reflect some of the readings afforded by *GFP Bunny*. They show the same image of Alba and me together, each topped by a different French word: ART, MEDIAS, SCIENCE, ETHIQUE, RELIGION, FAMILLE⁸. Between December 3 and December 13, 2000, parallel to radio (Radio France and Radio France Internationale), print (*Le Monde*, *Libération*, *Transfert*), 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, I feel, as it allowed me to address the Parisian public directly. I will continue to develop new strategies to pursue Alba's liberation.

Parallel to this effort, transgenic art evolves. One new direction involves the creation of nanoscale three-dimensional structures built of amino acids. This "proteic art", or "protein art" can be experienced in many forms, including in vivo, in vitro, and expanded into larger settings, such as rapid-prototype models and online navigational spaces. A second new direction involves complex interactive transgenic environments with multiple organisms and biobots, biological robots partially regulated by internal transgenic micro-organism. A discussion of these developments follows.

Proteins as Art

While the first phase of *Genesis* focused on the creation and the mutation of a synthetic gene through Web participation, the second phase, carried out in 2000/2001, focused on the protein produced by the synthetic gene, the *Genesis* protein⁹, and on new works that examine the cultural implications of proteins as fetish objects.

A critical stance is manifested throughout the *Genesis* project by following scientifically

accurate methods in the real production and visualization of a gene and a protein that I have invented and which have absolutely no function or value in biology. Rather than explicating or illustrating scientific principles, the *Genesis* project complicates and obfuscates the extreme simplification and reduction of standard molecular biology descriptions of life processes, reinstating social and historical contextualization at the core of the debate. In its genomic and proteomic manifestations, the *Genesis* project continues to reveal new readings and possibilities.

Protein production is a fundamental aspect of life. Multiple research centers around the world are currently focusing their initiatives on sequencing, organizing, and analyzing the genomes of both simple and complex organisms, from bacteria to human beings. After genomics (the study of genes and their function) comes proteomics (the study of proteins and their function). Proteomics, the dominant research agenda in molecular biology in the post-genomic world, focuses on the visualization of the three-dimensional structure of proteins produced by sequenced genes. It is also concerned with the study of the structure and functionality of these proteins, among many other important aspects, such as similarity among proteins found in different organisms. The second phase of *Genesis* critically investigates the logic, the methods, and the symbolism of proteomics, as well as its potential as a domain of artmaking.

In order to arrive at the visualization of the *Genesis* protein, I first explored aspects of its two-dimensional structure: its hydrophilicity and hydrophobicity¹⁰. Membranes in an aqueous environment have an attractive or repulsive response to water. The material composition of the membrane and its corresponding surface chemistry determine the interaction with water. This phenomenon is known as hydrophilicity (affinity for water) or hydrophobicity (little or no tendency to absorb water). The next step was to compare the predicted folding pattern of the *Genesis* protein to another known protein to which it is similar: Chorion. Research in the database of the National Center for Biotechnology Information (which includes all known proteins in all catalogued life forms) indicates that the predicted structure of the *Genesis* protein is functionally related to the Chorion protein found in *Ceratitis capitata* (Mediterranean fruit fly), since it is 39% similar to it. The coincidence (in structural similarity between *Genesis* and the Chorion protein) is particularly significant

in the context of the transgenic artwork *Genesis*, since Chorion is the protein that forms the membrane which serves mainly as a protective barrier for a developing embryo.

With the goal of producing a tangible rendition of the nanostructure of the *Genesis* protein, I researched protein fold homology using the Protein Data Bank, operated by the Research Collaboratory for Structural Bioinformatics (RCSB). I then produced a digital visualization of the *Genesis* protein's three-dimensional structure¹¹. This three-dimensional dataset was used to produce both digital and physical



Eduardo Kac, *Genesis Protein*, VRML and PDB, 2001
December 3-13, 2000.

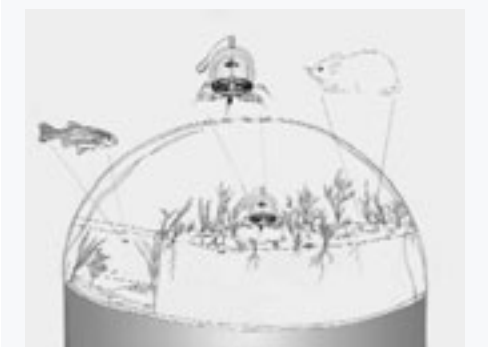
Courtesy Julia Friedman Gallery, Chicago.



Eduardo Kac, *Transcription Jewels*, 2001.
Glass, purified Genesis DNA, gold, wood.

Courtesy Julia Friedman Gallery, Chicago.

Courtesy, Julia Friedman Gallery, Chicago.



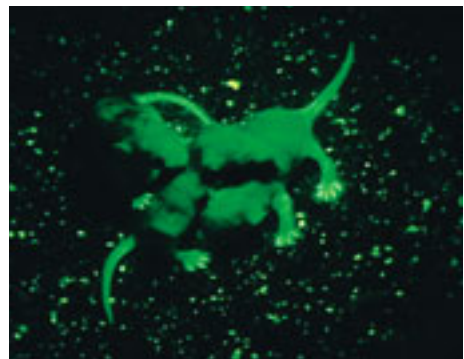
Eduardo Kac, *The Eighth Day*, 2000/01.
Illustration: Anna Yu

in biology to name the process during which the genetic information is “transcribed” from DNA into RNA. One “jewel” is a 2 genie bottle in clear glass with gold ornaments and 65 mg of purified *Genesis* DNA inside. “Purified DNA” means that countless copies of the DNA have been isolated from the bacteria in which they were produced and accumulated and filtrated in a vial. The gene is seen here out of the context of the body, its meaning intentionally reduced to a formal entity to reveal that without acknowledgment of the vital roles played by organism and environment, the “priceless” gene can become “worthless”. The other “jewel” is an equally small gold cast of the three-dimensional structure of the *Genesis* protein. By displaying the emblematic elements of the biotech revolution (the gene and the protein) as coveted valuables, “Transcription Jewels” makes an ironic commentary on the process of commodification of the most minute aspects of life. Both the purified gene in “Transcription Jewels” and its protein are not derived from a natural organism, but rather were created specifically for the artwork *Genesis*. Instead of a “genie” inside the bottle one finds the new panacea, the gene. No wishes of immortality, beauty, or intelligence are granted by the inert and isolated gene sealed inside the miniature bottle. As a result, the irony gains a critical and humorous twist through the fact that the “precious commodity” is devoid of any real, practical application in biology.

All pieces described and discussed above, including the net installation with live bacteria, were presented together in my solo exhibition *Genesis*, realized at Julia Friedman Gallery, in Chicago, between May 4 and June 2, 2001. The multiple mutations experienced biologically by the bacteria and graphically by the images, texts, and systems that compose the exhibition, reveal that the alleged supremacy of the so-called “master molecule” must be questioned. The *Genesis* project makes evident that “life” is no longer purely and simply a bio-chemical phenomenon. Instead, it states that we must consider life as a complex system at the crossroads between belief systems, economic principles, legal parameters, political directives, scientific laws, and cultural constructs.

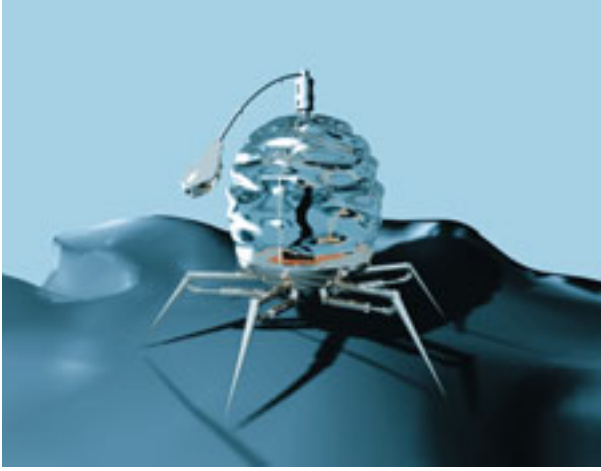
versions of the protein. The digital version is a fully navigable web object rendered both as VRML (Virtual Reality Modeling Language) and PDB (Protein Data Bank) formats, to enable upclose inspection of its complex volumetric structure. The physical rendition is a small solid object produced via rapid-prototyping, to convey in tangible form the fragility of this molecular object¹². This object was used as a mold for casting the final form of the protein used in the creation of the *Transcription Jewels*.

“Transcription Jewels” is a set of two objects encased in a custom-made round wooden box. The word “transcription” is the term employed



Eduardo Kac, *The Eighth Day*, 2000/01.
Stills: Isa Gordon

Courtesy Institute for Studies in the Arts,
Arizona State University, Tempe



Courtesy Institute for Studies in the Arts,
Arizona State University, Tempe

Eduardo Kac, *The Eighth Day*, 2000/01. Illustrations: James Stewart

The Eighth Day, a Transgenic Net Installation

The Eighth Day is a transgenic artwork that investigates the new ecology of fluorescent creatures that is evolving worldwide. I developed this work between 2000 and 2001 at the Institute for Studies in the Arts, Arizona State University, Tempe¹³. While fluorescent creatures are being developed in isolation in laboratories, seen collectively they form the nucleus of a new and emerging synthetic bioluminescent system. 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.

The Eighth Day presents an expansion of biodiversity beyond wildtype life forms. As a self-contained artificial ecological system 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 through the cloning of a gene that codes for the production of green fluorescent protein (GFP). As a result, all creatures express the gene through bioluminescence visible with the naked eye. The transgenic creatures in *The Eighth Day* are GFP plants, GFP amoeba, GFP fish, and GFP mice. A biobot is a robot with an active biological element within its body which 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 slowly go up and down, or to move about, throughout the exhibition. Ascending and descending motion becomes a visual sign of increase (ascent) and decrease (descent) of amoebal activity. 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 ascending and descending motion provide Web participants with a new perspective of the environment.

The biobot has a biomorphic form and the “amoebal brain” is visible through the transparent bioreactor. 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.

Conclusion

Quite clearly, genetic engineering will continue to have profound consequences in art as well as in the social, medical, political, and economic spheres of life. As an artist I am interested in reflecting on the multiple social implications of genetics, from unacceptable abuse to its hopeful promises, from the notion of “code” to the question of translation, from the synthesis of genes to the process of mutation, from the metaphors employed by biotechnology to the fetishization of genes and proteins, from simple reductive narratives to complex views that account for environmental influences.. The urgent task is to unpack the implicit meanings of the biotechnology revolution and, through artmaking, contribute to the creation of alternative views, thus expanding the language of genetics to make it more accessible and inclusive.

Notes

- 1 Peter Tomaz Dobrila and Aleksandra Kostic (eds.), *Eduardo Kac: Telepresence, Biotelematics, Transgenic Art*, KIBLA, Maribor 2000. Texts by: Annick Bureau, Edward A. Shanken, Christiane Paul, Aleksandra Kostic, Suzana Milevska, Machiko Kusahara, Gerfried Stocker, Steve Tomasula, Eduardo Kac. See also: <<http://www.ekac.org>>.
- 2 Kac, E. “Transgenic Art,” in: *Leonardo Electronic Almanac*, Volume 6, Number 11, 1998. Also: <<http://www.ekac.org/transgenic.html>>. Republished in Gerfried Stocker and Christine Schöpf (eds.), in: *Ars Electronica 99—Life Science*, pp. 289–296, Springer, Vienna/New York 1999
- 3 Kac, E., “Genesis,” Gerfried Stocker and Christine Schöpf (eds.), in: *Ars Electronica 99—Life Science*, pp. 310–313, Springer, Vienna, New York 1999. Also: <<http://www.ekac.org/geninfo.html>>. *Genesis* was carried out with 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.
- 4 Kac, E. “GFP Bunny,” in: Dobrila, Peter T.; Kostic, Aleksandra (eds.), *Eduardo Kac: Telepresence, Biotelematics, and Transgenic Art*, Kibla, Maribor 2000, pp. 101–131. Also: <<http://www.ekac.org/gfpbunny.html>>.
- 5 Cook, Gareth. “Cross hare: hop and glow,” in: *Boston Globe*, 9/17/2000, p. A01.
- 6 For a bibliography on transgenic art, see: <<http://www.ekac.org/transartbiblio.html>>.
- 7 <<http://sprocket.telab.artic.edu/ekac/bunnybook.html>>
- 8 These posters have also been shown in two gallery exhibitions: *Dystopia + Identity in the Age of Global Communications*, curated by Cristine Wang, Tribes Gallery, New York, 2000; and *Under the Skin*, curated by Ske Dinkla, Renate Heidt Heller and Cornelia Brueninghaus-Knubel, Wilhelm Lehbruck Museum, Duisburg, 2001. See also: *Under the Skin*, exhibition catalogue (Ostfilden-Ruit, Germany: Hatje Cantz Verlag, 2001).
- 9 In actuality, genes do not “produce” proteins. As Richard Lewontin clearly explains: “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,” in: *Science*, Vol. 291. p.1264. 16 February 2001.
- 10 Special thanks to Dr. Murray Robinson, Head of Cancer Program, Amgen, Thousand Oaks, CA.
- 11 Protein visualization was carried out with the assistance of Charles Kazilek and Laura Eggink, Bioluminescence Laboratory, Arizona State University, Tempe.
- 12 Rapid prototyping was developed with the assistance of Dan Collins and James Stewart, Prism Lab, Arizona State University, Tempe.
- 13 The *Eighth Day* team: Richard Loveless, Dan Collins, Sheila Britton, Jeffery (Alan) Rawls, Jean Wilson-Rawls, Barbara Eschbach, Julia Friedman, Isa Gordon, Charles Kazilek, Ozzie Kidane, George Pawl, Kelly Phillips, David Lorig, Frances Salas, and James Stewart. Additional thanks to Andras Nagy, Samuel Lunenfeld Research Institute, Toronto; Richard Firtel, University of California, San Diego; Chi-Bin Chien, University of Utah, Salt Lake City, and Neal Stewart, University of North Carolina at Greensboro. 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 through December 14, 2001. Exhibition location: Computer Commons Gallery, Arizona State University, Tempe (with the support of the Institute of Studies in the Arts). Live link and documentation can be found at: <<http://www.ekac.org/8thday.html>>.