The Ethics of Experiential Engagement with the Manipulation of Life

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Recent developments in the life sciences have had a fundamental effect and affect on individual and communal perceptions of life. Some of these developments present a profound departure from cultural (and, some might say) biological perceptions of what life is and what can be done with it. The ways in which these developments are being presented to the wider community play into current socioeconomic and political agendas. The ability to manipulate life not only creates new forms of life and partial life, but also forces us to reevaluate different understandings of life and the dissolving boundaries in the life continuum.

The technological application of knowledge in the life sciences created a wide array of responses from non-biologists who comment on the various aspects of the manipulations of living systems. Among them are a growing number of artists who engage with different levels of manipulation of living systems. This work draws a considerable amount of criticism. Ethicists, philosophers, writers, and fellow artists respond to the so-called biological art phenomena as well as to the larger issues concerning research, development, and application of the life sciences, biotechnologies, biomedical research, and agriculture. Much of the critique is valid and warranted; this includes questioning the motivations of artists and funding bodies who support biological arts, issues concerning the responsibilities of artists toward life-forms that are presented in artistic contexts, and the risk that works of art that are intended to warn about and critique trends in the application of the life sciences will instead end up normalizing and domesticating these developments. However, in many cases this critique is being marred by the misunderstandings of the different levels of engagement with life, overwhelmed by the complexities of life processes and outcomes, and the subscriptions to prevailing hyperbole discourses.

We would like to argue for the ethical, cultural, and political importance of experiential engagement with life manipulation, as it can be an effective methodology to confront

the complexities and to contest dominant ideologies regarding the life sciences. For the scope of this chapter, the narratives we would like to question with our “wet hands” are the narratives of life as a coded program—“biology as information”—and the way it serves the ideology and rhetoric of Western society advancing toward a false perception of total control over life and the technologically mediated victimless utopia.

Life Is not a Coded Program, and We Are not Our DNA

The mainstream discourse regarding the life sciences in the popular media, social sciences, the arts, and even, to a certain extent, the biological sciences themselves, seems to focus on genetics and molecular biology—even when the processes discussed have little or nothing to do with that level of biological intervention.

There is a direct relationship between this type of discourse and cybernetics and information theory. This correlation is partly based on a linear technological/historical narrative; biological revolution follows the digital revolution. This linearity can be seen as following a path of least resistance by applying established narratives to new phenomena, as much as the will to emulate the high-tech bubble (to do with success rates and short-term return on capital investment), rather than as following scientific findings. Applying the metaphors of the digital age to the life sciences acts (partly) as reinforcement of established power dynamics; the familiar and successful metaphors of “the dot com boom” draw a direct correlation from the digital revolution to the biological one while concealing some fundamental differences between the two. This way, the same economic model and market-driven product development is being used in connection with life and software/hardware.

For example, intellectual property laws as they apply to software are very different when applied to living entities; economic benefits from software/hardware are usually much more direct, and the revenue is earned faster, than when they are applied to biotech; risk assessments concerning software/hardware are shorter-term and different in nature from the risks associated with new biomedical and agricultural products. Recent investments and developments in genome mapping techniques may have advanced the knowledge of gene mapping; however, the promised utopian scenarios of understanding life and curing diseases are slow to follow. This is not to underestimate the advance in molecular knowledge, but rather a critique of the DNA mania (André Pichot)¹ or genohype (Neil Holtzman).² Furthermore, looking at life under the constraint of the metaphor of the code may lead to misunderstandings about the mechanisms of life, and certainly will limit the potential for different understandings which are not compatible with this metaphor.

Also, the mechanisms of life are enormously complex, and it is easier for us, who are “locked” within our own physiology, to try and make sense of life through simplistic cause-effect formulas. “We are our DNA” is one of these simplistic and misleading rhetorical statements.

The problem is that many of the developments in biomedical research do not adhere so neatly to information theory, and the origin of their development and the conceptual framework that brought them about are often neglected and ignored. However, many people from different disciplines are consciously and unconsciously conforming to this pervasive discourse.

Case Studies

We are concerned with the many examples of critiques of the life sciences which are based on what can only be described as sloppy research and misunderstandings of basic biological concepts, such as the difference between genetic engineering and tissue engineering (molecular manipulation and its effects versus cellular intervention). There is a need for correct terminology rather than careless use of generic terms in order for a meaningful dialogue to occur.

A report presented at the Wellcome Trust Biomedical Ethics Summer School at St. Annes College, Oxford, in September 2005 suggests that while the debate between scientists and social scientists and other humanities scholars may be fruitful, the latter are “intimidated by the complexity of the science, . . . This suggests a training need: To find ways to familiarise social scientists and humanities researchers with neuroscience, and to equip them to liaise with neuroscientists in a competent manner.”³ The same can apply to other streams of the life sciences as much as it should apply in reverse; scientists who would like to comment seriously about social and cultural issues should engage with the relevant discourses or at least get factual details correct. As will be outlined below, the main frame of reference concerning developments in the life sciences, and in particular their applications (whether technoscientific or cultural-philosophical), tend to be monodimensional in focus. This seems to be the case in which a narrow band is used to discuss the entire array of complex interrelationships between different aspects and levels of manipulation of life. Ironically, both the proponents and the opponents of biotechnological developments are mostly promoting one narrative—a reductionist view that manipulation of life through modern biology happens only at the molecular (genetic) level. As a result, shared discourses tend to have the same frame of mind and use the same metaphors concerning genetic manipulation to deal with other forms of biological engagement.

An example of this common phenomenon is Carol Gigliotti’s article in *AI & Society*.⁴ Social scientists discussing bioart in this magazine is the first associative connection between biology and information theory. Gigliotti titles her article “Leonardo’s Choice: The Ethics of Artists Working with Genetic Technologies.” However, the body text discusses two main case studies. One concerns the transgenic work of Eduardo Kac; the other, the Tissue Culture & Art Project—the authors—who do not work with genetic technologies at all, but rather with tissue technologies. Furthermore, key words suggested for the

article are “Animals—Biogenetics—Ethics—Aesthetics—Ecocentrism—Anthropomorphism—Animal rights—New media.” Biogenetics? Somehow, we do not think that her article deals with the debunking of the notion of spontaneous creation of life; it seems that it is more a combination of two buzz words: “bio” and “genetics.”

Throughout the article Gigliotti uses various terms in regard to both case studies, such as “genetics,” “transgenic,” and “biotechnology,” as well as the awkward term “biogenetic art.” There is no apparent logic to the use of the different terms in the different contexts, which leads the reader to suspect that Gigliotti may not know, or may not be careful in her use of, general terms among the different terminologies involved with the life sciences. It seems that in this article everything biological is genetic (it might be true, if one holds a very reductionist view that life is only about origin or development),⁵ and the author is not considering that genetics or transgenic procedures are different from other levels of engagement with life, such as the cellular, the tissue, or the organ level.

These kinds of factual inaccuracies make it very difficult to engage in the very important and relevant issues raised by Gigliotti which question the anti-anthropocentric intentions of artists who use animals or parts of animals for their artistic research. (Unfortunately, the scope of this chapter does not allow a further discussion of this issue.)

The same pattern of “genohype”⁶ (using the terms “biology” and “genetics” as if there are synonymous) occurs in the following discussion by two social scientists with interest and previous writing in regard to bioart, Steve Baker and Carol Gigliotti:

Abstract: This dialogue concerns the nature of ethical responsibility in contemporary art practice, and its relation to questions of creativity; the role of writing in shaping the perception of *transgenic art* and related practices; and the problems that may be associated with trusting artists to act with integrity in the uncharted waters of their enthusiastic engagement with genetic technologies.

Keywords: Art practice, Transgenic art, Ethics, Aesthetics, Genetics, Postmodernism.⁷

Furthermore, Gigliotti is very much aware of the power of metaphors and the effect of metaphors on further thinking and conceptualization. Referring to her statement “we are all transgenic,” she writes:

I wanted to throw the reader, the artist, the writer, the techno-theorist, the student, who appreciated my very specific points in earlier parts of the essay, a *metaphoric hook upon which they might begin or continue their own thinking*. The fact that there is a vast amount of genetic similarity between organisms, including humans, and we are all related by a shared evolutionary history, is the basis for the idea that we are all transgenic, and the basis, as well, for notions of a bio-centric compassion. *What current transgenic technologies are doing, however, is based on a flawed application of this similarity by reducing complex behaviours to single genes completely apart from the context of the formations of those behaviours. The problem with using what might be construed as an ambiguous metaphor is that it, too, might be misread and misapplied.*

Here is an example of either misunderstanding or sloppy use of terms. “Transgenic” is a technical and specific term that relates to the transfer of genes from another species or breed to another. The fact that organisms share “a vast amount of genetic similarity” is what makes the practice of transgenics possible. It can be argued that we are all transgenic through horizontal gene transfer via viruses and other biological agents, but it seems that is not what Gigliotti is referring to. It is also peculiar that Gigliotti is herself conducting a reductionist analysis by grouping all biological art under the umbrella of genetic art.

Gigliotti does not follow what she advocated: “*the idea that a confrontation with the complexity of a topic or issue precludes the necessity of confronting ethical choices embedded in that complexity.*”⁸ She critiques the ethics of artists working with tissue culture, without looking at the complexities within the relations between tissue culture and ethical treatment of animals. Furthermore, she is falling into the trap of genohype and the reductionist view of biology and biological art. To some extent, biological art that deals with other nongenetic forms of manipulation can be used as a way to counterbalance the view of life as determined solely by the DNA code. This is done by presenting the complexity of life and its interdependent relations with the environment; the development of living or semi-living entities is affected by and is effecting its surroundings rather than a “coded program” imposed on the environment.

Also, these artists remind us, in a way, how our understanding of life is not only limited but also filtered by our biology—by our anthropocentric makeup. Examples range from the authors’ practice as part of the Tissue Culture & Art Project⁹ (see figure 8.1), in which we are using tissue technologies as a medium of artistic investigation, to artists who are working at the level of the organism and ecologies, such as Phil Ross¹⁰ and Brandon Ballengée.¹¹ Another example is the artistic work of Paul Vanouse, who does work with DNA, but with the intention to disprove genetic determinism, as in the piece *The Relative Velocity Inscription Device*.¹²

Genohype or DNA mania rhetoric is playing into the hands of the discourse Gigliotti opposes. When one reduces life to the code or abstracts the complexity into its chemical components, the visceral sentient life is being pushed farther away. As Noble notes: “What the genes do is to contain the database from which the system can be reconstructed. They are the ‘eternal’ replicators. They don’t die, but outside of organism they also don’t live.”¹³ (. . . and react, and respond, and bleed, and may experience suffering and pleasure).

This inability to distinguish genetic engineering from tissue culture/tissue engineering leads to the following example and, as will be discussed later, presents an opening to an interesting case in which technology helps to obscure its victims even from the eyes of the most avid watchdogs.

In her essay Gigliotti identifies the correlation between developments in genetic engineering and the increase in the use of animals in biomedical research, mainly through the use of knockout mice:

Figure 8.2 *Tissue Engineered Steak No. 1*, by Tissue Culture and Art Project, 2000–2001. Prenatal sheep skeletal muscle and biodegradable PGA polymer scaffold. This was the first attempt to use tissue engineering for meat production without the need to slaughter animals. Part of the Oron Catts and Ionat Zurr Research Fellowship in Tissue Engineering and Fabrication, Massachusetts General Hospital/Harvard Medical School.

take a biopsy from an animal and proliferate the cells in vitro and over a matrix—hence growing/constructing a tissue-engineered meat for consumption as food.

The first steak we grew was made out of prenatal sheep cells (skeletal muscle). We used cells harvested as part of research into tissue engineering techniques in utero. The steak was grown from an animal that was not yet born. In theory, this work presents a future in which there will be meat (or animal protein-rich food) for people who reject eating meat based on animal welfare considerations, and the killing and suffering of animals destined for food consumption will be reduced. Furthermore, ecological and economic problems associated with the food industry (such as growing grains to feed the animals and keeping them in basic conditions) can be reduced dramatically.¹⁸

However, current methods of tissue culture require the use of animal-derived products as a substantial part of the nutrients provided to the cells, as well as an essential part of various tissue culture procedures.¹⁹ This point about tissue culture seemed (until recently)

Figure 8.3 *Disembodied Cuisine* installation, Nantes, France, by Tissue Culture and Art Project, 2003. Photo by Axel Heise.

to go unnoticed by the advocates of its use as a replacement for animal experimentation. The abstraction of these animal products in the technology associated with tissue culture served to obscure the very real victims from the eyes of organizations such as PETA and the European Coalition to End Animal Experimentation. For example, as a rough estimate (based on our experience with growing in vitro meat), growing around 10 grams of tissue will require serum from a whole calf (500 ml.), which is killed solely for the purpose of producing the serum.

The Art History Narrative

As mentioned above, Gigliotti is not alone in her “biology = genetics” view. In the context of the emerging area of biological art, much of the discussion of biological art seems to follow a neat, but problematic, linear historical narrative. This narrative is not so different from the general genohype in its outcomes, but its intentions are specific to the field. Nevertheless, it can illustrate the problems associated with the patterns that lead to the

limited public engagement with biology, and focus on only one aspect of the biotechnological story.

Many scholars draw a direct line from genetic art (use genetic algorithms to generate artificial life entities and/or computer-generated objects and forms) to biological art.²⁰ In order to rationalize this leap from computer-generated art to art that involves the manipulation of biological life, the proponents of such narratives take the view of biological life as being all about the code; that the artists and the work involved with biological art deal with the “code” of life. One can speculate that the combination of genotype and the need for cohesive narrative leads to ignoring the complexity of the different levels of engagement with life.

This proposition leads to an assumption of a linear, controlled, and progressive history of biological art that seems to be the line of choice of art historians, curators, and theorists who cannot cope with the multiplicity of sources, concerns, motivations, backgrounds, and references of biological art. The need to create a seemingly coherent, yet simplistic, narrative to explain the somewhat abrupt appearance of biological art created an array of swiftly forced postulations regarding the origins and progression of the field.

Even though practitioners in the field have diverse backgrounds ranging from formalist and conventional art through eco-art to body art, in the eyes of published art historians, biological art seems to be linked to, and to have originated from, digital art, possibly in an attempt to draw a deterministic lineage of progression in technologically based art. This line propagates a capitalist ideological stance that sees knowledge production and utilization as an inevitable, deterministic, and unstoppable progression of unidirectional growth. One example is the curatorial premise of the upcoming exhibition titled “Genesis! Creation in the Age of Electronics”:

... it was not before the development of air pumps that we could say that “the heart pumps blood.” Before the age of information, we could not understand that the genome was a program, ...

Is creation a haphazard construction shaped by accidents and contexts or does it require a program, with defined sets and rules? How has information, program and other concepts from the age of computer sciences structured how we think of creation? And what are—if any—alternative ways of creating in art and science? This is what the exhibition Genesis! is about.²¹

Fox-Keller warns of the discourse of “genetic program”: “in identifying genetic continuity and change as the sole fundament of evolution, it contributed powerfully to the polarization of debates over the relative force of genes and environment in such highly charged arenas as eugenics and the “heredity” of intelligence and other behavioral attributes.”²²

“Bioart” is far from being a coherent movement with a common origin. Most artists who work with the manipulation of living systems seem to dislike the term “bioart” and

would rather distance themselves from being bunched with the other so-called bioartists. The art historians' and curators' desire to cluster these discrete modes of operation under a unifying banner is understandable, but the forced fitting of a common history and lineage is inappropriate.

Community Versus Data: Cells Versus DNA

DNA never acts outside the context of a cell. And we each inherit much more than our DNA. We inherit the egg cell from our mother with all its machinery, including mitochondria, ribosomes, and other cytoplasmic components, such as the proteins that enter the nucleus to initiate DNA transcription. These proteins are, initially at least, those encoded by the mother's genes. As Brenner said, "the correct level of abstraction is the cell and not the genome."²³

Contra Oyama: I want to argue that taking the cell rather than the gene as a unit of development does make a difference: not only does it yield a significant conceptual gain in the attempt to understand development, it also permits better conformation to the facts of development as we know them.²⁴

The issue is that many of the developments in biomedical research do not so neatly adhere to information theory, and the origin of their development and the conceptual framework that brought them about are often neglected and ignored. We argue that the developments in regenerative medicine (such as therapeutic cloning, stem cell research, tissue engineering) can be traced back to early cell theory and to the work of Alexis Carrel in 1912, rather than to that of Watson and Crick in 1953.

We would like to emphasize the importance of the issue. As explained by Noble:

... at this stage of our exploration of life, we need to be ready for a basic re-think. ... It requires that we develop ways of thinking about integration that are as rigorous as our reductionist procedures, but different. This is a major change. It has implications beyond the purely scientific. It means changing our philosophy, in the full sense of the term.²⁵

Decisions that are made now in regard to the type of application of biomedical research tend to conform to the reductionist view of life. In many cases these decisions (and more often the critique of these decisions) are being made from a conceptual and ontological framework that is not relevant to the actuality of the processes and outcomes.

This chapter does not underestimate the importance and significance of the field of molecular biology. Also, as discussed by Thacker, the relationships between information theory and cybernetics, and the field of molecular biology, are closely related, but the two niches mutated their respective meanings. Thacker continues to argue that genomics rematerialized the information rather than virtualized the biological material. It is interesting to note that although he discusses the problems associated with the concept of

information and the concept of life, he himself, when discussing regenerative medicine, feels compelled to insert it into the "Decoding" section of his book,²⁶ but not as a technology that "debugs" the information/cybernetic analogy. We would prefer to relate regenerative medicine to fragmenting, mixing, and reconstituting life. For example, fragmenting can be seen as isolating cells or tissues; mixing involves culturing/coculturing; and reconstitution refers to embodying the result either in a new host body or in a new kind of "body" or vessel (bioreactor/technoscientific body).

As a critique of the reductionism of much genomic-based research, Thacker quotes Canguilhem:

... these relationships [organism and its environment] are not simply a matter of information processing, but of informatic-based understandings of biological life that is inseparable from the material, meaning-making process of the organism: Biology must therefore first consider the living as a meaningful being. . . . To live is to spread out; it is to organize a milieu starting from a central reference point that cannot itself be referred to without losing its original meaning.²⁷

Thacker also offers Lewontin's new view of genetics as a "triple Helix" of genes, organism, and the environment.²⁸ However, the problem that rises from that metaphor is that it is still rooted in the code/informatics view of life. It is not the double helix that interacts with the environment, but rather a whole organism (or part of an organism) that exists, grows, and changes together with its environment. Noble goes further, arguing that "... the statements suggest that organisms are defined only by their genes; whereas in truth they are also defined by the very varied ways in which genes actually operate within a living cell, and these gene expression patterns are most certainly influenced by the outside world."²⁹

It seems that even in the field of genetics we are witnessing some fundamental problems with conceiving life in relation to the metaphors of information and cybernetics. The situation becomes even more acute when this conceptual frame of mind is applied to regenerative medicine, stem cells, and therapeutic cloning: not only by the biologist who works in the field but also by people supporting the field, such as engineers and biomaterial scientists. The "language" of the code not only perpetuates misunderstanding regarding the processes involved; it also severely limits the development of new understandings which are "true" to the biological materials involved. This is becoming apparent in the growing field of synthetic biology, which attempts to develop genetically modified organisms as building blocks for engineering ends, using the logic of engineering to create these biological circuits:

"You write the same software and put it into different computers, and their behavior is quite different," Mr. You said. "If we think of a cell as a computer, it's much more complex than the computers we're used to."

For that reason, some scientists say, it might be difficult ever to make biological engineering as predictable as bridge construction.

"There is no such thing as a standard component, because even a standard component works differently depending on the environment," Professor Arnold of Caltech said. "The expectation that you can type in a sequence and can predict what a circuit will do is far from reality and always will be."³⁰

Tissue engineers, who are working mostly at the level of cells and tissue, seem to be just as aware of the problems of applying engineering logic to living systems:

The cell is at the center of the developmental world. Truth be told, we cannot, as tissue engineers, actually claim to engineer tissues. We can only engineer an environment for cells that might induce, enhance, or mediate their developmental processes. But progress has been buoyed by biomimetics—lifting recipes from nature for the design of tissue engineering systems.³¹

As some of the current major developments in the life sciences are concerned with cell development (rather than only genetics), it is worthwhile to look at cell theory and tissue culture at the beginning of the twentieth century. These theories are concerned with the materiality of "life" and the environment in which it is grown. Rather than on code, there is an emphasis on communal interrelationships as a reference point.

In Canguilhem's discussion of the early formation of cell theory, there are a couple of narratives concerning ideas and research on cellular formation. The first is the narrative of individuation and its relation to the bigger "whole," and the second is of the community. Metaphors of community, labor, and the nation-state have been attached to the conceptual understandings of the way cells, tissues, and organs are operating within and without a body:

In fact, the cell is both an anatomical and a functional notion, referring both to a fundamental building block and to an individual labor subsumed by, and contributing to, a larger process. What is certain is that affective and social values of cooperation and association lurk more or less discreetly in the background of the developing cell theory.³²

H. G. Wells, Julian Huxley, and G. P. Wells refer to cells in organs as individuals in a city (by extension the body is a nation-state), and to cells in vitro as individuals with no purpose and structure:

Naturally, when they are parts of a living body the cells are disciplined, they do not wander about where they like, growing actively and reproducing themselves, as the cells in culture do. An organ such as the brain or liver is like the City during working hours, a tissue culture is like Regent's Park on a Bank Holiday, a spectacle of rather futile freedom.³³

Animal cells are a complex system which behaves and multiplies according to its environment and the signals it receives from its surrounding cells. Hence the same cells will behave differently in the body and in a dish because of their context. In the case of embryonic stem cells, which have the ability to differentiate to any cell type, they receive many of their “differentiation instructions” from surrounding cells. This is especially relevant to cells grown in culture.

In a way, while the metaphors surrounding information theory and the code refer to some sort of a central processing unit (or a control mechanism that operates on the materiality), cell theory allows autonomy to parts which can operate, evolve, and mutate independently and in direct relation to their surrounding. Oken anticipated the theory of degrees of individuality. This was more than just a presentiment; it anticipated that techniques of cell and tissue culture would teach contemporary biologists about differences between what Hans Peterson called the “individual life” and the “professional life” of cells.³⁴

As always, metaphors are a fruitful source for new understandings and misunderstandings. What is unique to the dominant metaphors developing in cell biology is that they tend to be more morphic and adaptive to their environment, yet at the same time they tend to become anthropomorphic in their individual and communal “behavior.” Hence, cells’ “behavior” is receiving (almost) the same level and type of agency as the individual cell of a social organism.

Getting Close to the Victim and the Need for Informed Experiential Engagement

As demonstrated above, much of the perception of development in the life sciences is marred by misappropriation of prevailing metaphors, ideologies, and hype. Working in laboratories with living materials, we were faced with the complexity of life in its multi-levels. How living entities (whether genes, cells, organs, organisms, or populations) cannot be separated from their environmental factors, and are always in flux.

In Fox Keller’s words: “To be sure, the concept of program has changed considerably since the 1960s, but it has not lost its facile assimilation with information, or, more generally, its disembodied aura.”³⁵ One way to understand the different concerns and the complexity of the different levels of engagement with life, as well as a way to reveal the obscured casualties of the new technologies, is by hands-on experiential engagement. By working hands-on with tissue technologies, we were confronted with the “hidden victims” of this field: the animals from which the tissues are obtained, and animal-derived ingredients in the nutrient media as well as the waste created (mainly in the form of plastic labware), which has a lasting effect on the environment. To use another metaphor, being in the lab is akin to going to the slaughterhouse rather than to the supermarket to obtain beef. This approach can be, and has been, utilized by artists who are working with biology;

Figure 8.4 *Victimless Leather*, a prototype of a stitchless jacket grown in a technoscientific “body,” by Tissue Culture and Art Project, 2004. Biodegradable polymer connective tissue and bone cells, original dimensions variable.

for the non-scientist, the “wet” experience in the laboratory involving some degree of life manipulation can be seen not only as an ethical conduct but also as a political act. A political act that goes beyond the democratization of the technology, to the act of breaking down dominant discourses, dogmas, and metaphors to reveal new understandings of life and the power structure it operates within. This experiential engagement can sometimes reveal that critique leveled against some biological art is embedded within the dominant dogma (figure 8.4).

Notes

1. Quoted in Denis Noble, *The Music of Life: Biology Beyond the Genome* (Oxford University Press, 2006), pp. 3–6.
2. A term coined by Neil Holtzman to describe the discourse of exaggerated claims and overstatements concerning DNA and the Human Genome Project (1999), pp. 409–410.
3. Quoted in <http://www.lancs.ac.uk/fss/sociology/events/showevent.php?ID=620>, CSS, CSEC, & CESAGen Conference, “Getting Underneath the Fact.”
4. For the whole issue (vol. 20, no. 1 [2006], see <http://www.eciad.bc.ca/~gigliotti/gtanimal/TOC.htm>.
5. The *American Heritage Dictionary* defines “genetic” as follows:
 1. a. Of or relating to genetics or genes.
 - b. Affecting or determined by genes: genetic diseases.
 2. Of, relating to, or influenced by the origin or development of something.
 3. Linguistics. Of or relating to the relationship between or among languages that are descendants of the same protolanguage.
6. For more, see Oron Catts and Ionat Zurr “Big Pigs, Small Wings,” *Culture Machine* (online journal), Biopolitics, no. 7 (2005). <http://culturemachine.tees.ac.uk/Cmach/Backissues/j007/Articles/zurrcatts.htm>.
7. Steve Baker and Carol Gigliotti, “We Have Always Been Transgenic: A Dialogue,” *AI & Society*, 20 (January 2006), special issue, *Genetic Technologies and Animals*.
8. Ibid.
9. <http://www.tca.uwa.edu.au>.
10. <http://www.philross.org>.
11. http://greenmuseum.org/artist_index.php?artist_id=19.
12. http://www.beap.org/2004/index.php?z=exhibitions/bio_arti&h=bio&h=bio.
13. Denis Noble, *The Music of Life*, p. 21.
14. Carol Gigliotti, “Leonardo’s Choice: The Ethics of Artists Working with Genetic Technologies,” *AI & Society*, 20 (January 2006), special issue, *Genetic Technologies and Animals*.

15. <http://www.eceae.org/english/alternatives.html>.
16. http://www.peta.org/mc/factsheet_display.asp?ID=87.
17. PETA correspondence, February 10, 2003.
18. The president of PETA has contacted the authors to inquire about collaborating with the TC&A on a project in which a biopsy will be taken from her body to grow a semi-living steak. She will consume this steak as an act of (self) cannibalism to highlight that from her perspective, any consumption of meat can be considered cannibalism.
19. From the chief executive officer of the Australian Association for Humane Research, Inc. (AAHR):

Fetal calf serum (FCS) . . . is commonly used in cell and tissue cultures as a source of nutrients, hormones and growth factors. Many researchers however, may not be aware of the ethical and scientific concerns regarding its use.

Methods of collection:

After slaughter and bleeding of the cow at an abattoir, the mother's uterus containing the calf fetus is removed during the evisceration process . . . and transferred to the blood collection room. A needle is then inserted between the fetus's ribs directly into its heart and the blood is vacuumed into a sterile collection bag. This process is aimed at minimising the risk of contamination of the serum with micro-organisms from the fetus and its environment. Only fetuses over the age of three months are used otherwise the heart is considered too small.

. . . Australian authorities have confirmed that fetuses here should have already died from anoxia prior to serum collection, however according to scientific literature this is not likely to be the case.

. . . It has been estimated that around half a million litres of raw FCS is produced each year worldwide which equates to the harvesting of more than one million bovine fetuses annually. Some sources have suggested that the actual figure may be closer to two million fetuses per year. 30 June 2006.
20. Some examples can be found in the writings of scholars such as Gerfried Stocker, Suzanne Anker, Ingeborg Reichle, and others.
21. An attachment to an e-mail sent to us on December 12, 2006.
22. Evelyn Fox Keller, "Beyond the Gene but Beneath the Skin," in Eva M. Neumann-Held and Christoph Rehmann-Sutter, eds., *Genes in Development: Re-reading the Molecular Paradigm* (Durham, N.C., 2006), p. 292.
23. Denis Noble, *The Music of Life*, pp. x–xi.
24. Quoted in Fox-Keller, "Beyond the Gene but Beneath the Skin," p. 294.
25. Denis Noble, *The Music of Life*, p. 41.
26. Eugene Thacker, *The Global Genome: Biotechnology, Politics, and Culture* (Cambridge, Mass., 2005).
27. *Ibid.*, p. 89.
28. *Ibid.*
29. Denis Noble, *The Music of Life*, p. 19.

30. "Custom-Made Microbes, at Your Service," <http://www.nytimes.com/2006/01/17/science/17synt.html?emc=eta1>.
31. Gordana Vunjak-Novakovic, "Transplants Made for Order," *The Scientist*. <http://www.the-scientist.com/article/daily/24539/> September 2006.
32. Quoted in François Delaporte, ed., *A Vital Rationalist: Selected Writings from Georges Canguilhem*, trans. Arthur Goldhammer (New York, 2000), p. 162.
33. H. G. Wells, Julian Huxley, and G. P. Wells, *The Science of Life: A Summary of Contemporary Knowledge About Life and Its Possibilities*, vol. 1 (London), p. 29.
34. Quoted in Delaporte, *A Vital Rationalist*, p. 169.
35. Fox Keller, "Beyond the Gene but Beneath the Skin," p. 306.