

SCIENCE AND SOCIETY

The influence of genetics on contemporary art

Dorothy Nelkin and Suzanne Anker

Contemporary visual artists are incorporating genetic concepts into their work, and this work has become prominently featured in numerous museum and gallery exhibitions. Such art uses visual images that represent the language of genomics, the values affected by genetic understanding of the body and the implications of bioengineering. Here, we present various examples of how artists depict aspects of genetics as cultural icons and symbols; in particular, their focus on DNA as information and on the commercialization of genetics research material.

Since the early 1990s, works of art inspired by genetics and biotechnology have become a prominent feature in museum and gallery exhibits in the United States, Western Europe and Australia. Universities, art schools and professional associations have convened exhibitions and symposia on the 'sci-art' relationship and, in particular, on how visual artists incorporate genetic concepts into their work. Institutes such as **The Wellcome Trust** and the **Calouste Gulbenkian Foundation** in the United Kingdom are funding collaborations between scientists and artists, and are underwriting exhibitions of genetic art. Science museums, such as the **Mendel Museum of Genetics** in Brno in the Czech Republic and the **American Museum of Natural History** in New York City, USA, are also including works of art in their educational installations.

The artists whose work is exhibited in such venues are using visual images to represent the language of genomics, the values that are affected by the genetic understanding of the body and the implications of bioengineering. Artists have long been attracted to science, medicine and technology, and today many artists seem to have a special appetite for the issues and associations that are emerging from recent discoveries in genetics.

Why is there this gravitation towards genetics — a complex and highly abstract science, a science of the invisible, which has little obvious visual appeal? Today's artists are perpetuating an established aesthetic tradition by engaging scientific discoveries, principles and ideas, and by re-interpreting the implications of scientific application. In the past, artists have incorporated insights from the most prominent sciences and technologies of their day¹. When anatomy was emerging as a science, Andreas Vesalius and Leonardo Da Vinci sought anatomical precision in their depictions of the human body. The splitting of the atom influenced the work of early European abstractionists, such as Kandinsky and Mondrian. With the development of the microscope and, later, visual instruments based on X-rays, the quest for an invisible reality became an idiom in the work of artists including Redon, Klee and Duchamp. At present, contemporary artists are responding to the deluge of discoveries in genetics by integrating the iconography evoked by this science into their styles of figuration.

One of the crucial aspects of genetics that has caught the attention of visual artists is the movement of this science from code to commerce, as genetic material has become a valued commodity. In a molecular vision, the body is defined as a text, a 'coded script' of information. And with the commercialization of genetic research, the cells and genes that make up the body have become products: mined, banked and patented — reduced, in effect to commodities, to fungible goods. What follows is a selection of examples that illustrate the artistic responses to the genetic revolution. For more on this topic, see REF. 2.



Figure 1 | **Code Noah** by Tony Cragg (1988). Bronze (275 cm × 100 cm × 100 cm). Collection of Mr and Mrs Ware Travelstead. Courtesy of the Marion Goodman Gallery, New York City, USA.



Figure 2 | *Zoosemiotics: Primates, Frog, Gazelle, Fish* [detail] by Suzanne Anker (1993). Glass vessel, water, steel, hydrocol, metallic pigment. (Installation: 3.7 cm × 8.2 cm × 1.52 m). Courtesy of [Universal Concepts Unlimited, New York City, USA](#).

The language of the molecular vision
The signs and symbols of contemporary genetics — the double helix and the chromosomes — emerged from concepts developed in the mid-1940s, as physicists sought to extend their work to a new frontier. By applying the laws of matter to living systems, they began to reshape the biological sciences. By the 1950s, scientists were re-conceptualizing the body, transforming it, in effect, from a morphological structure to a molecular organization, from organism to text, from flesh and blood to information. The language of ‘information theory’ (developed by physicists in the 1950s to deal statistically with the content of information) implied that living things were assembled according to instructions encoded in the chromosomes and that an organism could best be understood through decoding these instructions. As they perceived the body as a decipherable text, geneticists increasingly used linguistic metaphors in descriptions of their work³.

The physicist Irwin Schroedinger was among the first to use the language of codes to describe living things. In his seminal text *What is Life?* (1943), he identified a rhetorical model of the gene, calling it a ‘codescript’⁴. This semiotic language would later influence Watson, Crick, Gamow and other biologists. Watson and Crick described the gene sequence as an ‘information system’⁵; and George Gamow invoked the word ‘translation’ to explain how proteins are assembled

from the information encoded in DNA⁶. By the 1970s, human biology had been redefined and transformed into a science that was predicated on molecular assumptions⁷.

A molecular vision now dominates the theories and methods of the biological sciences. Biologists in the molecular age are seeking to answer questions about the essential characteristics of human life, the truth that underlies appearances and the ways in which our genetic endowment is influenced by our interaction with culture⁸. By reducing life itself to DNA, the molecular vision has displaced the visceral references that were once used to describe the body and to define the work of traditional biology. Now that it is perceived as language or code, DNA has become a cultural metaphor, a creative means to probe the secret of life. We are but a sequence of nucleic acids, a ‘codescript’ of information.

As high-magnification microscopes, scanning devices (such as magnetic resonance imaging) and computer simulations generate new ways to visualize biological information, artists have turned their attention to images from this dynamic field. They are appropriating genetic iconography to explore the meaning of human identity; and they are borrowing the signs and symbols of genetics to visually map the links between DNA and the corporeal body. Significantly, the reductionist language of codes and codescripts shifted their earlier representational models of the body towards the abstract.

Representation of DNA in art

Artists represent the DNA molecule in at least three ways — as an icon, an index and a symbol (as described in more detail below). This nomenclature, introduced by philosopher Charles Sanders Peirce to describe the kinds of sign that are operative in linguistic structures⁹, is also a functional way to understand the operation of language metaphors in DNA-inspired art.

DNA as an icon. In representing genetic material, artists focus on different levels of cellular and molecular organization, from the helical structure of DNA to the chromosomes to the genes. In an iconic image, representation directly resembles the subject portrayed. Both the double helix and the metaphase chromosomes appear in painting, sculpture, photography and video installations as genetic icons. For example, in *Code Noah* (1988; FIG. 1), Tony Cragg welds together toy teddy bears, cast in bronze, to construct a spiral chain. Consisting of two intersecting bands, the sculpture uses the

physical structure of the double helix. By playfully building a molecular architecture with children’s toy animals, Cragg suggests that nature can be culturally constructed.

So, too, chromosomes (from the Greek meaning ‘coloured bodies’) have become cultural icons, representing the instructional language of the body. To the artists who use these images, the body seems to write itself as a string of semiotic fragments in an information system. The installation pieces of Suzanne Anker, such as *Zoosemiotics* (1993; FIG. 2), use greatly enlarged chromosomes that look like ancient alphabets. According to art historians Barbara Maria Stafford and Frances Terpak, her work translates the genetic code into a visual shorthand for living systems, a *lingua franca* of life. In effect, the X-shapes of the chromosomes become playful, cavorting bodies¹⁰.

DNA as an index. Visual artists also represent the DNA molecule as an index — a type of pictorialization that is indirectly produced. For example, an autoradiograph — a barcode pattern that is produced chemically by an individual’s genetic code — is a marker of personal identity. Autoradiographs, which consist of light and dark bands, form patterns in discrete rows. Because they are virtually unique for each individual, they are commonly used for criminal investigation and in cases of disputed paternity or inheritance claims. Dennis Ashbaugh, in 1992, was one of the first artists to incorporate these marking patterns in paintings. His large-scale paintings of autoradiographs, such as *Designer Gene* (1992; FIG. 3), use light and colour that are reminiscent of the atmospheric colour fields of Mark Rothko’s paintings. However, Ashbaugh’s message is derived from the technological ability to translate hidden reality into a visible pattern, to reveal an inner code.

DNA as a symbol. The meaning of a symbol is based on convention. Gene sequences are represented symbolically by the letters A, C, G and T. Arranged in a linear sequence, the letters are acronyms for the four nucleotide bases. The arrangement of these letters is distinct for each individual as well as for all living matter: apart from identical twins, we all have our own genetic code. The genetic portrait has become a new genre in art. For example, Kevin Clarke’s portraits use the letters ACGT to convey the idea that genes are the essence of personal identity. His DNA portraits eliminate the subject’s visual appearance and instead use that person’s genetic code as a way to reveal the uniqueness of an individual. Clarke sequences the individual’s DNA from a blood sample

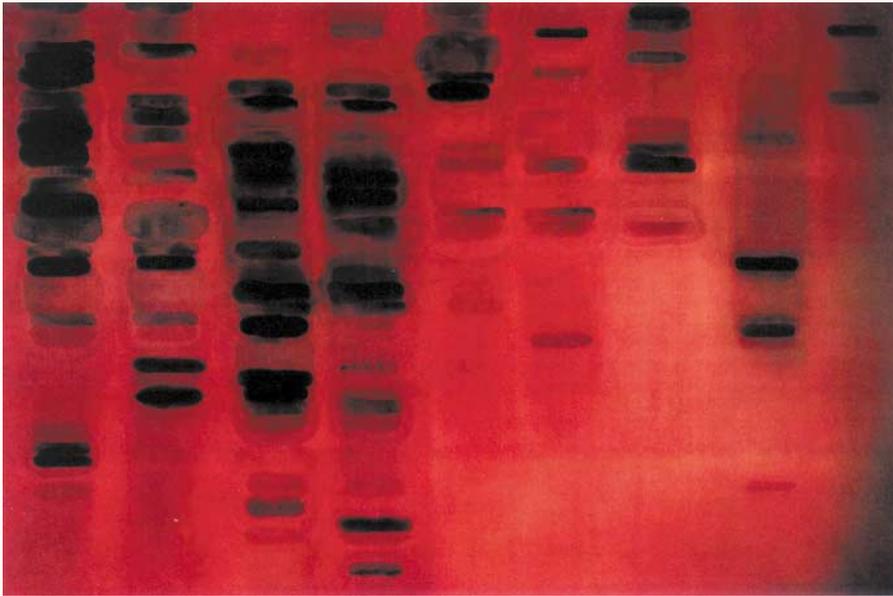


Figure 3 | *Designer Gene* by Dennis Ashbaugh (1992). Mixed media on canvas (185.4 cm × 274.3 cm). Collection: Artist. Courtesy of Dennis Ashbaugh.

and then overlays the nucleotide sequence on an image that is associated symbolically with the person. For example, he superimposed the nucleotide sequence of James Watson on library shelves and the sequence of artist Jeff Koons (who depicts the banality of consumer culture) on a slot machine (FIG. 4). Similarly, British artist Marc Quinn created a genetic portrait of Sir John Sulston, the former director of The Wellcome Trust Sanger Centre. The portrait, shown at the National Portrait Gallery in London, UK, is comprised of colonies grown from bacterial cells that contain segments of Sulston's DNA.

Clarke, Quinn and other artists, including Inigo Mangano-Ovalle, Gary Schneider and Steve Miller, appropriate the language of genetics as a way to explore the essence of their subjects. Their interpretations might differ from those of scientists. Some artists, who come from a humanist tradition with holistic premises and who depend on contextual understanding, question and criticize reductionist models. Others express awe or reverence for the power of DNA. Still others reference social concerns in their work, such as the possibility of a new eugenics. Their creations, like all art, are open to many interpretations. Whereas scientists seek precision, artists welcome ambiguity. So, Clarke's genetic portraits can be interpreted as reductionist — or they can be viewed as an effort to reveal the inner domain of his subject, the secret of life. Cragg's teddy bear sculpture (FIG. 1) invokes the double helix, but it is also a playful satire on the commodity culture in which this science functions.

Reducing human life with all its social complexity to mere code or information seems to oversimplify and even denigrate the integrity of living things. Artists are particularly sensitive to this issue. More troubling is the movement from information to commercialization, which seems to undermine the social worth of human beings. This has inspired some artists to address the controversial implications of the commercialization of genetics research material and the reduction of DNA to a commodity.

The commodification of DNA
The techniques of biotechnology have transformed the body into marketable bio-material. The human body tissue that is obtained from medical biopsies is increasingly valuable as raw material for pharmaceutical products, DNA databases and even shampoos. But DNA samples also have commercial value as sources of genetic information¹¹.

References to cells and human tissue in the medical, scientific and popular literature use a language of commerce — that is, banking, investment, insurance, compensation and patenting. Pathologists regard banks of stored human tissue samples as 'treasure troves' for DNA research. Geneticists talk of 'prospecting' for genes. Cells, in the language of science, are extracted like a mineral, procured like a parcel of land, harvested like a crop, mined like a resource and banked like money. The body is a 'natural resource' — an abundant biosystem that can be divided and dissected down to the molecular level.

Commercializing and patenting human tissue — especially DNA — has troubled many observers because such practices violate common beliefs and emotional feelings about nature and our assumptions of personal control over one's body. The body is not just a neutral object; it is loaded with cultural and intimate associations¹². There exists a continuing tension between instrumental views of the body as a material object and its social and personal meanings for human beings. Is body tissue to be considered refuse that is freely available as raw material for commercial products? Or does it have inherent value as part of a person? Are genes the essence of an individual? Or are they, as a director of SmithKline Beecham purportedly claimed, "the currency of the future"¹³. What, exactly, distinguishes nature from artefact?

Artists are questioning the assumptions that underlie the commercialization of biological material by exploring the idea of turning tissues into artefacts — into marketable and patentable products. Larry Miller, for example, addresses the matter of control and ownership of the body, the notion that a person's DNA can be treated as an object — copyrighted, patented, bought and sold. His 1993 elegant, formal and official-looking certificate *Genetic Code Copyright* states that "I, a naturally born human being, do hereby forever copyright my

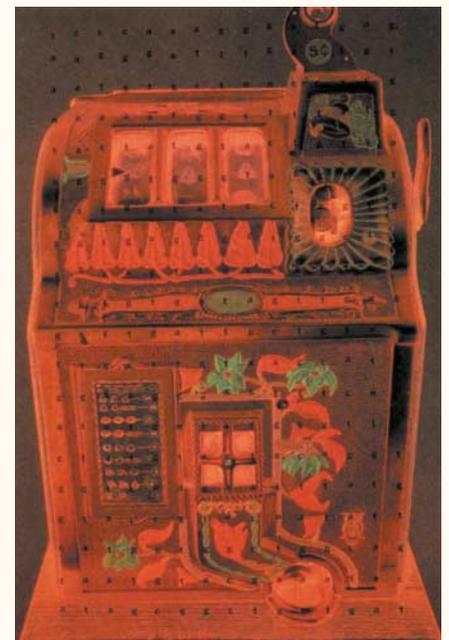


Figure 4 | *Portrait of Jeff Koons* by Kevin Clarke (1993). Cibachrome on aluminium (121.9 cm × 182.9 cm). Collection: Artist. Courtesy of Kevin Clarke. The nucleotide sequence is represented by the letters a, c, g and t that run across the surface of the picture.



Figure 5 | *Ecce Homo* by Bryan Crockett (2000). Marble on epoxy (76.2 cm × 101.6 cm × 177.8 cm). Collection of JGS, Inc. Courtesy of Lehmann Maupin Gallery, New York City, USA.

unique genetic code, however it may be scientifically determined, described or otherwise empirically expressed¹⁴. Miller's ironic work plays on the assumption that DNA is the essence of being human and the source of individual identity. And he mocks the idea that an individual's genetic code can be copyrighted and treated as a commodity, as if a person is but a 'widget'.

Miller was responding to the publicized and intuitively shocking decision in *Moore v. University of California*¹⁵. Moore had a rare form of hairy cell leukaemia and, in an attempt to treat the condition, his surgeon successfully removed his affected spleen. But then Moore discovered that his spleen cells had been patented as the Mo-Cell Line (patent number 4,438,032), and he sued his physician for malpractice and property theft. The Court, defending the need for patenting as essential to stimulate investment in biotechnology research, denied that Moore held proprietary rights to his own body tissue.

Ellen Levy also addresses the issue of patenting, but in a less sceptical way. She derives her work from actual patent applications, displaying data, graphs and technical notations that highlight the treatment of genes as commodities in a long line of inventions.

Among the many commercially available animal models for laboratory research is the Oncomouse, a transgenic mammal with an inserted human gene sequence that confers susceptibility to cancer¹⁶. The mouse, a biological model for the study of breast cancer, achieved a certain notoriety when, in 1988, it became the first genetically engineered animal to be patented (US patent number 4,736,866). Bryan Crockett's Oncomouse *Ecce Homo* (2000; FIG. 5) stands six feet tall and is intended, Crockett writes, to be "the ultimate actor of modern science ... human-kind's symbolic and literal stand-in personified"¹⁷.

In Crockett's exhibition, *Cultured* (2002), the artist portrays seven baby pink mice in marble and resin. They are actors in the theological tale of the seven deadly sins: *pride, envy, gluttony, anger, lust, greed and sloth*. The mouse called envy has human ears, referring to the human ears that have been grown experimentally on mice. Gluttony has been given a gene for obesity, representing a mouse that was created to study diabetes. This work is intended as a critique of the manipulation and patenting of living creatures, and the use of animals as instruments for research.

In Frank Moore's *Oz* (2000; FIG. 6), a colossal genetically engineered plant is embedded in a mound of golden coins. The environment is littered with piles of defunct furniture, cars, appliances, a farmhouse and other consumer products, while a giant bee leaves a trail of double helices in the sky. By depicting an apocalyptic end-of-the-world scenario, this meticulous and visionary painting projects a moral message, questioning the hubris of geneticists and bioengineers. The pot of gold is a lure, but the litter suggests the disasters that can result from the profitable experiments¹⁸.



Figure 6 | *Oz* by Frank Moore (2000). Oil on canvas on featherboard with road map on aluminium frame (42.5 cm × 301.25 cm). Collection: Howard Stein. Courtesy of Sperone Westwater Gallery, New York, USA.

Conclusions

Artists are adopting the signs and symbols of the molecular vision of life¹⁹. Through their images, they are questioning the reductionist premises of the contemporary biological sciences and suggesting their social implications. Are people simply the measure of their genes or are they products of history, personal experience, social relationships and cultural values? Is the self merely a sum of its biological parts or is it a more dynamic and interactive system that is shaped by culture and is mutable over time? What are the implications of patenting for human dignity and for the value of life itself?

Genetics has been integrated into the work of artists in other ways that we cannot accommodate in this article. Some artists are visually representing metamorphosis, mutation, cloning, assisted reproduction and transgenic experiments. There is, for example, a revival of monster images in art — a new grotesque²⁰. The chimaera, a frequent image throughout the history of art, has reappeared, often with references to transgenic experiments. Both monsters and chimaeras are classic themes in art history. Contemporary visual artists build on these motifs, developing new configurations in response to the crucial and compelling scientific developments of the molecular age.

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Online links

FURTHER INFORMATION

American Museum of Natural History: <http://www.amnh.org>

Calouste Gulbenkian Foundation: <http://www.gulbenkian.org.uk>

Geneculture: <http://www.geneculture.org>

Lehmann Maupin Gallery:

<http://www.ohwy.com/ny/lehmauga.htm>

Marion Goodman Gallery: <http://www.mariangoodman.com>

Mendel Museum of Genetics:

<http://www.mendel-museum.org>

National Portrait Gallery, London: <http://www.npg.org.uk>

Sperone Westwater:

<http://www.contemporaryart.com/speronewestwater>

The Wellcome Trust: <http://www.wellcome.ac.uk>

The Wellcome Trust Sanger Centre: <http://www.sanger.ac.uk>

Universal Concepts Unlimited, New York City:

<http://www.u-c-u.com>

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OPINION

Quantitative genetic analysis of natural populations

Allen J. Moore and Penelope F. Kukuk

Quantitative genetic studies in natural populations have been rare because they require large breeding programmes or known pedigrees. The relatedness that has been estimated from molecular markers can now be used to substitute for breeding, allowing studies of previously inaccessible species. Many behavioural ecologists have a sufficient number of markers and study species with characteristics that are amenable to this approach. It is now time to combine studies of selection with studies of genetic variation for a more complete understanding of behavioural evolution.

R. A. Fisher, one of the architects of the modern syntheses in evolutionary biology, showed how a knowledge of Mendelian inheritance was required to complete our understanding of evolution. Indeed, the first words of Fisher's seminal work were "Natural selection is not evolution"¹ (page vii), referring to the risk of ignoring the effects of

inheritance on evolution. Whereas phenotypes that do worse than others are eliminated by selection, the changes of a trait only persist over time in a population if there are genetic influences that underlie the variation of that trait, that is, if selection is filtered through the system of inheritance¹. So, changes that result from selection can be constrained or altered by the pattern of inheritance for a particular trait of interest². The most fundamental constraint is a lack of genetic variation, because if there is no underlying genetic variation, the changes that occur in response to selection do not persist to the next generation. In addition, if two traits share common genetic influences, then selection acting on one will necessarily change the other even if this second trait is not subject to direct selection. If selection pressures conflict, or the genetic association among traits is negative, then this too can act as a constraint and can delay or stop evolutionary changes.

Given the role of genetics in evolution, evolutionary interpretations of selection studies without information about the mode of inheritance can be misleading^{3,4}. It is therefore crucial to examine the extent of genetic variation in a population (genetic VARIANCE) and the genetic associations among traits (covariance), which are often conveniently expressed as HERITABILITIES and GENETIC CORRELATIONS, respectively (BOX 1). These parameters can then be assessed in combination with selection if we wish to extrapolate the potential EVOLUTIONARY TRAJECTORY of a set of traits². However, because of the difficulties of identifying genetic influences in most populations, researchers are often limited to studying patterns of selection alone and inferring evolution from this partial information. In addition, many characters of interest to evolutionary biologists (morphology, behaviour and LIFE-HISTORY CHARACTERS) are usually COMPLEX and therefore require a quantitative genetic approach, which can be even more daunting^{5–11}. However, recent advances in statistical methodology^{12–17} should facilitate the combined studies of natural selection and genetics in natural populations. In this article, we suggest how such studies might be conducted, with a particular focus on how these methods can be used to explore the evolution of behaviour. As we discuss, several conditions and assumptions must be met for the statistical methods to be applicable, so not all areas of research can capitalize on these developments. In addition, the methods are relatively untried, and the extent to which these methods are robust is unknown until more data are collected¹⁸. Nonetheless, we argue that behavioural ecologists in particular will benefit, as they are likely to study species with the required characteristics, including molecular markers and information on population structure, which facilitate the use of these statistical methods. Such studies will verify or refute their usefulness.

Natural quantitative genetics Perhaps more than most fields, behavioural ecology is characterized by studies that relate fitness to variation in behaviour, and that interpret behavioural patterns in an evolutionary context^{2–4}, but ignore genetics. This is not due to a lack of interest in the genetic contribution to behaviour^{9,10}. There are several barriers to examining patterns of genetics for ecologically relevant behaviour, mostly owing to the lack of tractable species to which previous methods could be applied⁸ (although avian studies have been a notable exception^{19,20}). First, behaviour is perhaps the ultimate complex character and is almost always