ARTIST'S ARTICLE

Art, Space and Hyperreality

An Artistic Exploration of Artificiality, Meaning and Boundaries within Astrobiological Practice

ANDY GRACIE

ABSTRACT

A dual exploration of scales both massive and minuscule has allowed the author to create artworks and experiments that combine cultures of microscopic organisms and data from space probes and planetary landers. Meanwhile, a gradual increase in the author's laboratory practice has led to a familiarity with in vitro processes and a corresponding theoretical examination of their significance and place in the cultural milieu. Central to these developments in the author's practice has been the emergence of notions and understandings of simulation theory that unify both nature-technology relationships and ongoing work with organic and living materials. The author describes his artistic experiments with hybrid ecosystems, robotics, artificial intelligence, space exploration and astrobiology and the threads and themes that have persisted throughout them.

This essay surveys certain recurring themes in the body of work I have carried out as an artist over the first years of this century. Although in many ways this work has traced a path through seemingly disparate fields and subjects—from techno-organic environments through space exploration and astrobiology—specific consistent and repetitive ideas have prevailed. For example, the problem of what constitutes reality and how perceptions and actions are influenced is one that I have regularly, although not always explicitly, addressed through my research and projects. In the following paragraphs, I discuss notions of manipulated relationships, examinations of boundary states and the relationship between in vitro processes and simulation theory. Needless to say, each of these fields demands and deserves much deeper analysis and discussion in its own right. However, in the space available here, I present an overview of how I have explored and associated such issues in relation to my own activities on the fuzzy border between art and science (Article Frontispiece).

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Article Frontispiece. Andy Gracie, close-up of *Deep Data Prototype 2*, 2009. (© Andy Gracie. Photo © Marco Antonio Lara Martinez.)

During the first decade of the 21st century, I was occupied mostly with making works that explored relationships between the "natural" and the "artificial" in response to the ever-closer entwining of technology and biology (for an example, see Color Plate A). The natural, in these cases, was usually embodied by living organisms such as insects, fish, plants or bacteria; the artificial was usually embodied by robotics, mechatronics and software systems incorporating elements of artificial intelligence (AI) or artificial life. I expedited their relationships and intercommunications with intermediaries in the form of wires, sensors, audio systems and various other techniques that exploit the information-carrying capacities of the electromagnetic spectrum and the information-generating characteristics of organic matter. Robots of various kinds became data-gathering platforms within this nexus, and they developed ways to mutate and contribute this data back to the system. I excluded human interactivity in terms of direct input, but I promoted and facilitated emergent relationships and behaviors among whichever combination of natural and artificial agents were present in each work. By making these artworks, therefore, I undertook an investigation into the potentials for collaboration and emergence between technology and nature in hermetic environments and into the interdependence that prevails among agents in a structured environment. I was interested in considering what is natural, what is artificial, where the boundaries between such states and definitions might lie and how they might be blurred or even dissolved [1].

Over the course of my ongoing artistic research and experiments, my explorations into hermetic systems, hybrid ecosystems, and the employment of technology as a mediator and provocateur of organic entities and processes led me to consider what would be the extreme limit of their application or, in other words, the ultimate hermetic techno-organic environment. My conclusions were that such an environment would go beyond terrestrial experiments such as Biosphere 2 [2] and that it could facilitate development of vast migration ships, such as those seen in both science fiction (for example, *Silent Running*) and in proposals by NASA and

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engineer Herman Potočnik, such as the space habitat known as the Stanford torus (Fig. 1) [3]. The fusion of technology and nature has as its ultimate vision the visiting, colonizing and even terraforming of distant planets—the perpetuation of human viability in space. Such ideas propose and demand a new expression of nature outside of and independent of nature itself, beyond the so-called *next nature* or *postnature* concepts that relate to our evolving relationships with environments and ecosystems on Earth [4]. To genuinely look at nature in separation from nature, then, the removal of context has to be absolute. A successful space-based biohabitat requires a derivative of nature that is artificial but convincingly representational in most, if not all, aspects and that is also completely functional. Following these connections and ideas, my new obsessions became the agency, application and possibilities of the organic in nonterrestrial environments, and how we explore and understand those environments.

Our presence and influence in space now span 58 years, since the launch of *Sputnik* in October 1957. That placement of a robotic entity into orbit suddenly and irreversibly enlarged our perceptual and sensory horizons, an expansion that has been ongoing ever since. Space is now teeming with robotic data-gathering and -processing platforms; a plethora of orbiters, landers, rovers and deep-space probes bristling with sensors, cameras, telescopes and communications systems enable us to place our augmented senses and perceptions at distances up to 17 light-hours away. On Earth is a complementary network of receivers, dishes, antennae and information centers, additional locations for our expanded sensory cortex. *Voyager 1* has recently stretched our horizons into interstellar space as it hurtles outward at 16 kilometers per second, and *Voyager 2, Pioneer 10* and *Pioneer 11* are reaching similar distances on other vectors. *Cassini*, *New Horizons*, *Dawn* and other craft are engaged in exploring and connecting us to the outer reaches of the solar system.

In *The Seven Mysteries of Life* [5], author Guy Murchie discusses twin horizons: the horizon of mystery and the horizon of knowledge. The two are inextricably linked. As the horizon of knowledge retreats before our advances and discoveries, the horizon of mystery precedes it, always presenting new unknowns and demanding new knowledge. In the physical sense, a symmetry is at work: The horizons move not only outward into space but also inward into microscopic and subatomic realms. The study of particle physics offers a vision of infinity as deep and mysterious as the boundaries of the universe. Our journey into new scales and territories began in earnest in the 17th century. In 1609, Galileo looked up at the Moon with his early telescopes and discovered "lofty mountains and deep valleys." In 1674, Van Leeuwenhoek discovered "animalcules" in water with his single-lens microscopes. Blaise Pascal spoke of how the sense of being poised between two abysses, "the invisible atomic world with its infinity of universes and the invisible cosmos, too big to see," brought with it a simultaneous feeling of wonder and horror [6]. The same journey between the extremes of scale has, of course, been effectively popularized in the famous animation *Powers of Ten*, by Charles and Ray Eames, and by much more recent Flash animations that are easily found on the Internet [7].

A subtext of many robotic explorations of other planets and moons and the pushing back of the horizon of knowledge has been the search for life, or for past or present conditions conducive to life. The results of such explorations have been pleasingly ambiguous or controversial (and thus always rich ground for artistic pickings). In 1976, *Viking* landers performed "Labeled Release" experiments on Martian soil to detect biological activity. Initial results from the first tests showed positive for metabolism, although later tests contradicted those findings. The validity of the first results are still heavily debated, with some scientists claiming that "extant microbial life on Mars" was indeed detected [8]. Currently, the Mars Science Laboratory, commonly known as the *Curiosity* rover, has as an explicit aspect of its mission the goals of determining the habitability of Mars, investigating the chemical building blocks of life, and identifying biological processes. ExoMars

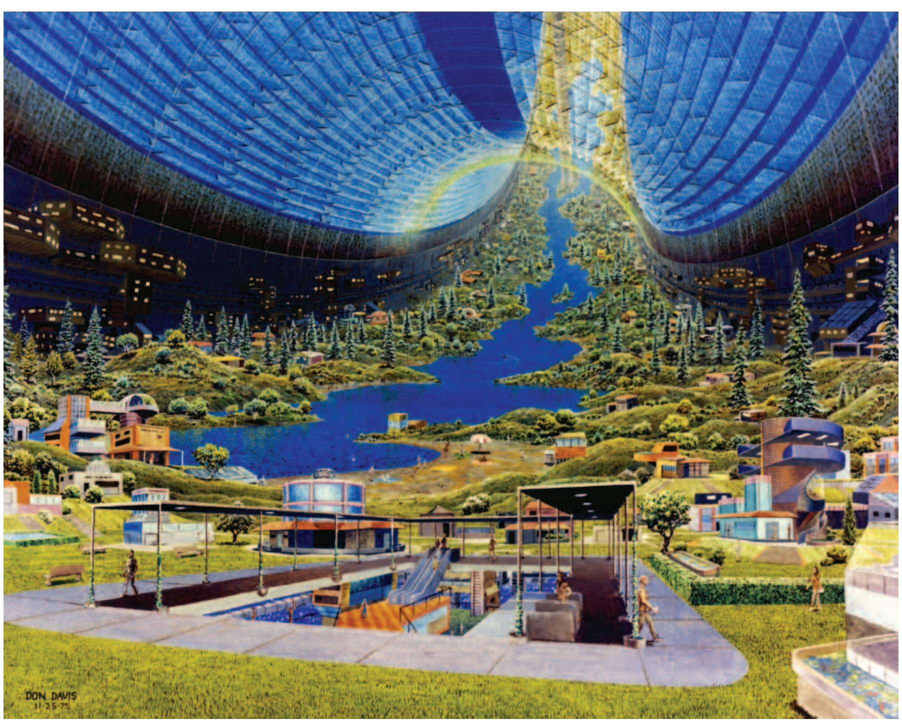

Fig. 1. Example of a Stanford torus space habitat, illustrated by Donald Davis. (Image courtesy of NASA Ames Research Center.)

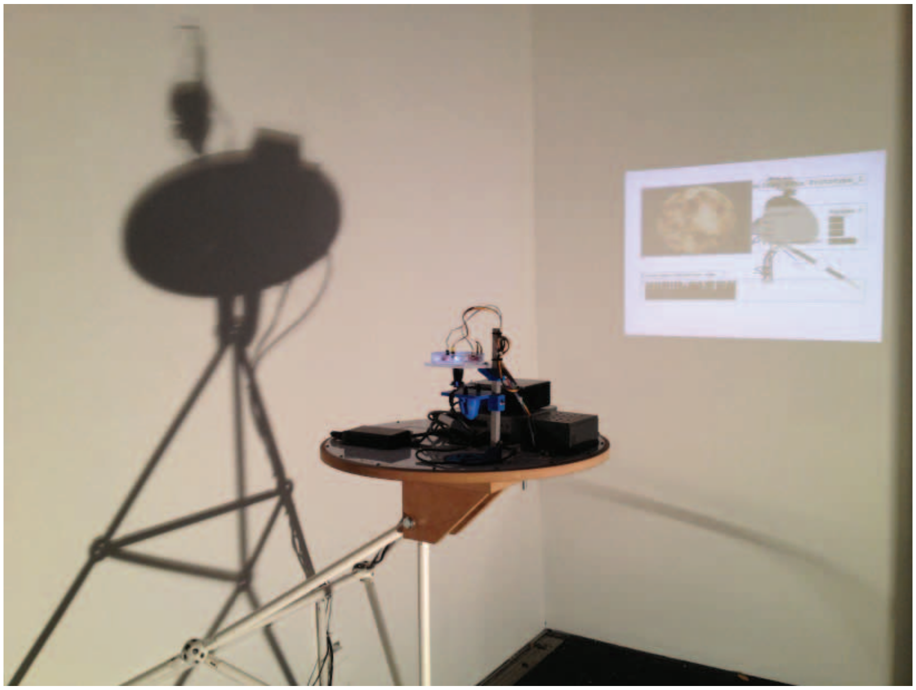

Fig. 2. Andy Gracie, *Deep Data Prototype 1*, 2009. Exhibited in *Yours Synthetically*, Ars Electronica Centre, 2013. (© Andy Gracie)

is a proposed future mission that aims to cast more light on these questions, while other life-hunting missions are planned for the moons Europa and Titan [9]. Concurrently, the discovery of exoplanets is gaining pace, and we are close to being able to concretely identify Earth-like planets in other solar systems [10].

These mounting questions and the need for coherent research into the possibility of life outside Earth have given rise to the relatively new scientific field of astrobiology, which aims to answer questions about life on Earth in order to imagine the possibilities of life elsewhere. Astrobiology has at its core a set of questions about the nature of life—what it is, how it happens, why it happens, under which circumstances it happens and what the boundaries of these circumstances might be. Our sample for answering these questions is obviously Earth, the only place where life has been detected, and terrestrial research into extremophile organisms living in acidic, hot or cold environments informs us about the boundaries of states in which life can exist. By investigating and attempting to answer questions about Earth's life to the best of our abilities and knowledge, we refine our questions about how and where to look for life on other planets, and we can extrapolate on the forms that viable life can take.

Since 2009, I have been making work that presents a cultural response to the practice and theory of astrobiology—its significance, its methodologies and its necessarily interdisciplinary organization. This work revisits my earlier projects that plugged robotic systems into organic systems, but this time the robots are not mine. Instead the robotic platforms are the multibillion-dollar, state-of-the-art space probes built and launched by the space agencies of the world. My artistic explorations of astrobiology began with the project series *Deep Data*, which I conceived as a direct way to span and connect the two abyssal scales that so daunted Pascal. *Deep Data* collects sensor information, via the NASA COHOWeb servers, from the deep-space probes *Pioneer*, *Voyager*, *Cassini* and *New Horizons* and uses it to modify the culture environments of terrestrial model organisms used in space bioresearch [11]. *Deep Data Prototype 1* (Fig. 2) harvests data from magnetometers aboard the *Pioneer* and *Voyager* probes and feeds it into a PDMS (polydimethylsiloxane) bioelectronic culture vessel housing live tardigrades, thereby abstracting a simple space simulation within the microorganisms' culture environment. The tardigrade is a remarkable creature, a polyextremophile microanimal that has already survived exposure to raw space aboard the European Biopan module of the Russian *Foton* capsule. Apart from its ability to withstand extreme conditions of various kinds, the tardigrade has a mechanism with which it can shut down its metabolism and enter a form of stasis, for decades if necessary. Fully understanding this mechanism holds obvious possibilities for the future of long-term space travel, and thus the organism is, in general, of great interest to astrobiologists. In *Deep Data Prototype 2* (Fig. 3 and Article Frontispiece) I placed photomutagenic seeds of another model organism, *Arabadopsis thalania*, under lighting conditions both real (as recorded by

Fig. 3. Andy Gracie, *Deep Data Prototype 2*, 2012. Exhibited in *Sin Semilla*, Universidad Nacional Autónoma de México, 2013. (© Andy Gracie. Photo © Marco Antonio Lara Martinez.)

space probes) and imagined (as envisaged in science fiction through the ages) of the Moon, Venus, Mars and Titan. In both projects, the poetic gesture allows terrestrial organisms to grow in certain conditions of the extraterrestrial environment while remaining here on Earth, and space data serves as a tool for sculpting the growth patterns and behaviors of the living organisms.

Plants, insects, amphibians, invertebrates and mammals have been flown into space for research since the beginning of the space age. From early biosatellites to the International Space Station (ISS), biological matter has been cultured in off-Earth environments, and from initial efforts to understand the body's reactions to physical elements of space life, the violence of launch and reentry, microgravity and cosmic radiation, the focus of inquiry has shifted to include biological changes that occur during and after space flight. Over the past three decades, space has become a laboratory [12]. Through experiments into aging, muscle wastage, gravitaxis, mating strategies, cell division and so on, we forge knowledge about how the human organism might need to adapt to a post-terrestrial future and how other terrestrial organisms might adapt to live on other planetary bodies.

The International Space Station currently houses, among many other biological modules, the EXPOSE facility. Its two modules, EXPOSE-E and EXPOSE-R, developed by the European Space Agency (ESA) and launched on *Progress* capsules from Baikonur, allow for the exposure of chemical and biological samples to space, and these modules have hosted a number of experiments to determine how terrestrial organisms might cope with extraterrestrial environments. One of the experiments onboard EXPOSE-E is PROCESS, a study that has special relevance to Titan, Saturn's largest moon and a place of great interest for the science of astrobiology. This experiment aims to study photochemical organic compounds in Earth's orbit, compounds that are also present in the dense hydrocarbon atmosphere of Titan and can yield clues about the formation of organic chemistry and the building blocks of life.

Titan has become a point of focus for me over the last three years. Its ontological boundaries harbor material relevant to several of my artistic obsessions: astrobiology, space probes and the origins, and possible extremes, of life. It is among the places in the solar system that we know best, and it is the one that, to date, seems most similar to Earth. Despite its lack of oxygen and temperatures of 179° below zero Celsius (or 94 Kelvin, in correct scientific terminology), Titan resembles Earth in its thick atmosphere, liquid cycle, continents and tectonic activity. For many scientists, it is a cryogenic "proto-Earth." Data from *Cassini* suggests that Titan might have a subsurface ocean of water mixed with ammonia; its atmosphere is rich in organic compounds and phenomena in the methane cycle that are comparable with those produced by organic life on Earth. So Titan, a rich and suggestive environment full of tantalizing clues and mysteries and ideas about life, serves as a metaphor for Earth [13].

While considering this potent metaphor, I simultaneously thought about a metaphor for the human, in the form of the fruit fly *Drosophila melanogaster*. This species has been a workhorse of genetic biology and developmental biology since the 1980s, and its genome was sequenced and published in 2000. About 75 percent of known human disease genes have a recognizable match in the genome of fruit flies, and 50 percent of fly protein sequences have mammalian homologs. Owing to these figures, the organism lends itself to research into many human diseases, especially neurodegenerative disorders, along with ageing, immunity and addiction. Its relatively short life cycle and propensity for mutation have made it an ideal candidate for evolutionary studies and a model for deeper research into inheritance and chromosome mechanics. It follows, of course, that *Drosophila* became a regular passenger aboard the space shuttle and on the ISS [14].

Fig. 4. Andy Gracie, *Drosophila Titanus*, 2011–ongoing. Microscope images of two (approximately) 50th-generation flies. (© Andy Gracie)

While embarking on a series of dioramas of the Xanadu area of Titan, where the *Huygens* probe landed in 2005—which dioramas will become increasingly cold until they are able to replicate the exotic organic chemistry and methane rain typical of Titan—I decided to bring these two metaphors—Titan for Earth and *Drosophila* for humanity—together. My project, *Drosophila Titanus* (Fig. 4), has been underway since early 2011 and will need to continue for at least a few more decades [15]. It is an embarkation upon a scientific process toward the impossible: creating a new species of *Drosophila* that potentially could live on Titan. Despite the impossibility of organic life surviving there, meaning and purpose are instilled in the work in a number of other loci and intertwined narratives. I undertook it partly to decipher the ways in which the artistic gesture can be found or interpreted within the scientific process—which has to eradicate the ambiguity, metaphor and poetry that art demands—and partly to explore the implications of artificial selection and prescriptive breeding, processes that have traditionally resulted in dark notions of superiority, such as eugenics, "designer babies" and the creation of new chimeras and monsters to satisfy economic or aesthetic demands.

The project, by necessity, has to address some darker issues, such as social Darwinism and its ultimate expression in eugenics (ironically pioneered by Darwin's cousin Francis

Galton, as was the common phrase “nature versus nurture”). The search for biological perfection and the notion of the ideal genome are deeply implicated in the practice of artificial selection. At the peak of the U.S. space program’s space-race astronaut training in the 1960s, the term “the right stuff” [16] was used to describe the qualities desired in the ideal astronaut candidate. It suggested not just a good military record and high levels of physical fitness and intelligence but also the appropriate political and moral codes of practice. It is interesting to consider which form of “the right stuff” successful individuals of *Drosophila* will need to display as the project progresses and selection pressures, and thus competition, intensify.

I keep the flies according to standard laboratory *Drosophila* procedure: i.e. in plastic vials with foam caps and an agar-based nutrient medium. Every two to three weeks, the cultures are “passaged” (transferred to new vials with fresh media). Control cultures are kept as well as the experimental ones. I have designed and implemented experiments, processes and apparatus that adjust the conditions in which the flies are living, and in which aesthetic considerations are given equal standing to those relating to scientific rigor, step by step and over many generations. Through an iterative process of adaptation and selection for lower temperatures, increased atmospheric pressure, altered atmospheric chemistry, varying light and dark sequences, and increased UV radiation, and over many generations, the flies gradually change. *Drosophila Titanus* is a conceptual work rooted in research and process. Under exhibition conditions, the project usually manifests as a timeline intended to communicate the methodologies, document the passing of generations of flies, and execute the delicate operation of discovering the artistic gesture (Fig. 5).

Whether a new species can be attained is uncertain, but maybe more interesting are the ongoing disagreement and multiple opinions about what and where the species boundary actually is, and how change can be perceived in a species. Close to the project’s heart is the study of the relationship between genotype and phenotype, a relationship that increasingly is seen as being at the core of evolutionary biology [17]. The complex interplay between genome and environment, and the ways that they are physically expressed as an organism seeks to adapt and survive, forms the scientific foundation of the work’s ongoing exploration. As genotype and phenotype begin to mutate and adapt, we enter the area of speciation, an important issue in evolutionary terms and on

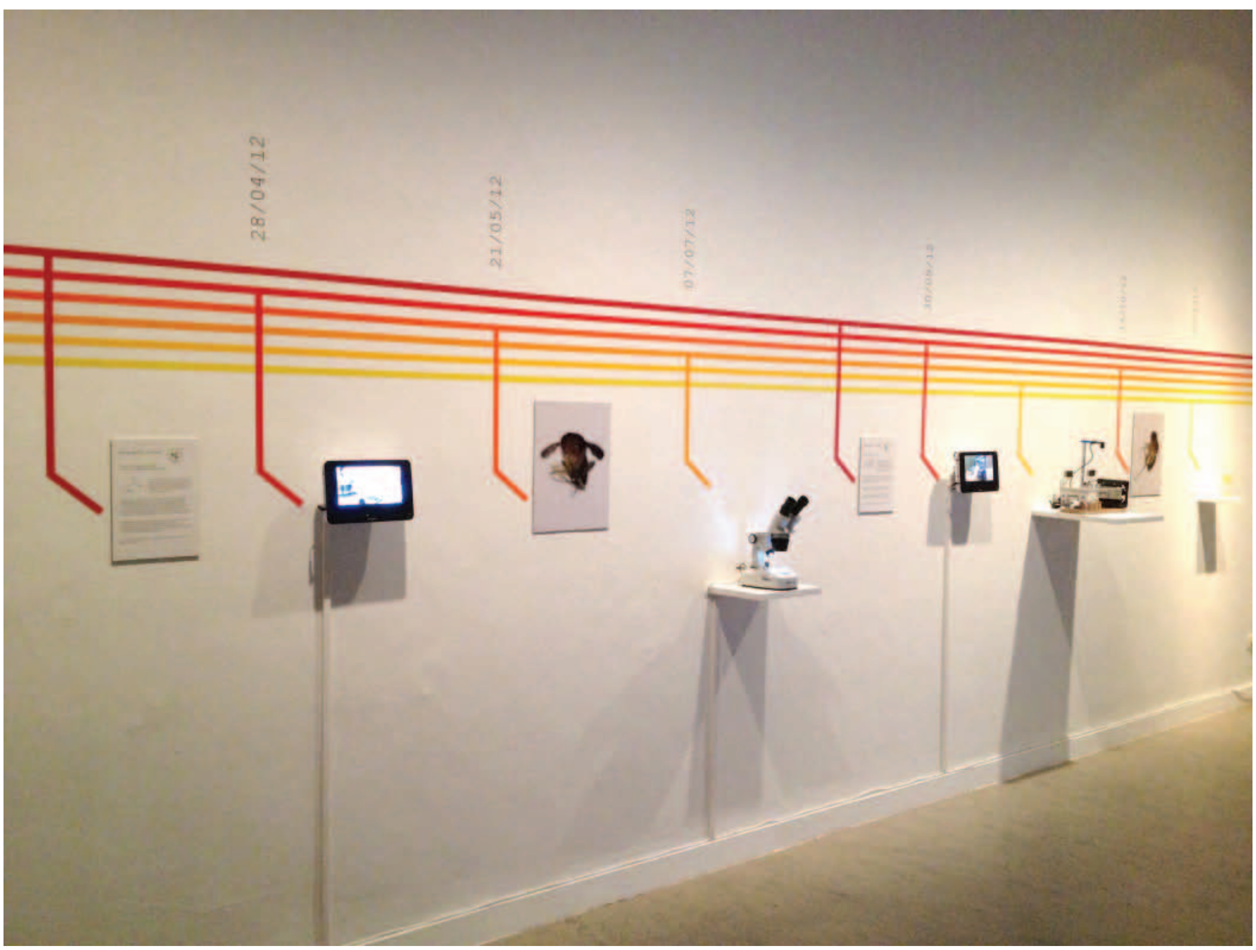

Fig. 5. *Drosophila Titanus* timeline. Exhibited in *Space Odyssey 2.0*, Z33, Hasselt, Belgium. (© Andy Gracie)

which little is agreed. The moment when one species splits into two separate and distinguishable species is under intense study, and *Drosophila* are at the forefront of this science [18]. Furthermore, here we enter the realm of the monster: the artificially created animal with no evolutionary purpose. The fly is created with the same procedures that have produced poodles, featherless chickens, puffy-eyed goldfish and corn on the cob. Weighing up the scientific, economic, ethical and aesthetic values of these creatures, and attempting to locate them within the concept of nature, is a moral and philosophical challenge.

Through analysis of the relationships between atmospheric density and gravity on Titan, scientists have surmised that a human being would need only strap on cardboard wings to be able to fly, with no other augmentation of or assistance to our species' standard musculature. *Drosophila Titanus* employs a mutant strain called vestigial wing, in which the wings are barely formed and (on Earth) practically useless. However, consistent with my intention to take artistic poetry and metaphor from scientific process is the notion that, in the dense atmosphere and low gravity of Titan, the tiny wings of these insects could be able to provide enough lift for flight. Of course, this would only be possible if the flies were able to get to Titan and, despite their intensive acclimatization, survive. The relationship between scientific process, impossibility and the artistic gesture is one that I have intended to make apparent throughout all the work I have produced over the years.

Recently, while making a deeper investigation into the biological mechanics of the fruit fly at the Biofilia lab at Aalto University in Helsinki [19], I began to culture *Drosophila* cells. This rigorous and meditative laboratory practice led me to ponder the origin and destiny of embryonic fly cells, which in turn led me to discover imaginal discs. In a variation on the usual process of cell differentiation during metamorphosis, *Drosophila* larvae, during the third instar larval stage, develop imaginal discs within the body. These disc-like lumps of cells are attached to the central nervous system and, during the pupal stage, migrate to appropriate sites in the body, where they will extrude into legs, antennae, eyes, mouthparts, wings and genitalia. With careful dissection of larvae, these discs can be removed and the various body parts can be grown ex vivo and in vitro [20]. In conventional laboratory practice, this process is used to study cell division, migration, gene expression and morphogenesis. In artistic laboratory practice, these structures suggest different potentials, such as prostheses, bodily modifications, organs ex-vivo, chimeras and monsters.

Fundamental to the practice of culturing cells and growing imaginal discs, as well as a host of other ex-vivo or in-vitro laboratory protocols, is the use of an incubator, or a bioreactor, and some form of culture or growth medium. It quickly becomes apparent that this conjunction of media and apparatus is a form of simulator. The cells and discs (and bacteria and fungi and neurons) all grow because of the sufficient simulation and replication of what can be semiotically perceived as habitual reality. The flux of nutrients, gas exchanges, temperature and lighting conditions are within the ranges of what the organic material would "expect" and provide it with the signals and materials needed to grow. Equally, certain of these parameters can be altered, or new ones added, to provide experimental frameworks for growth under foreign conditions while maintaining the satisfactory illusion of authenticity. Therefore, following this train of thought and examining it from the cultural perspective, we could say that such laboratory processes are situated within what Baudrillard and Eco termed *hyperreality*. If we substitute the consciousness of the organic matter for those essential processes that distinguish living from nonliving, then these processes are unable to distinguish between reality and a simulation of reality. This would be in line with Baudrillard's third stage of simulation: his "order of sorcery," where illusion prevails [21].

The classic "brain in a vat" thought experiment, in which an ex-vivo brain is wired to electrodes that create stimuli mimicking real sensations, connects directly to the notion of laboratory as simulator (Fig. 6). The brain in question has no way of knowing that it does not reside inside the cranium of a living organism, and it acts exactly as if it were, despite its lack of firsthand experience [22]. The illusion is complete. In the same way, organic matter in vitro grows only because, via the use of culture media and carefully modulated environmental conditions, a hyperreal parallel of the "real" has been created. This is an expression of semiotics and the application of biosemiotics, developed by Von Uexküll and Sebeok [23]. An organism—and we can extend this term to include components of organisms—reacts in fairly predictable ways according to the inputs it receives from its sense environment. Literally, this is "the virtual" as described by Deleuze [24] or, in De Landa's terms, "transcendental empiricism": the perception of information from direct sensory experience [25].

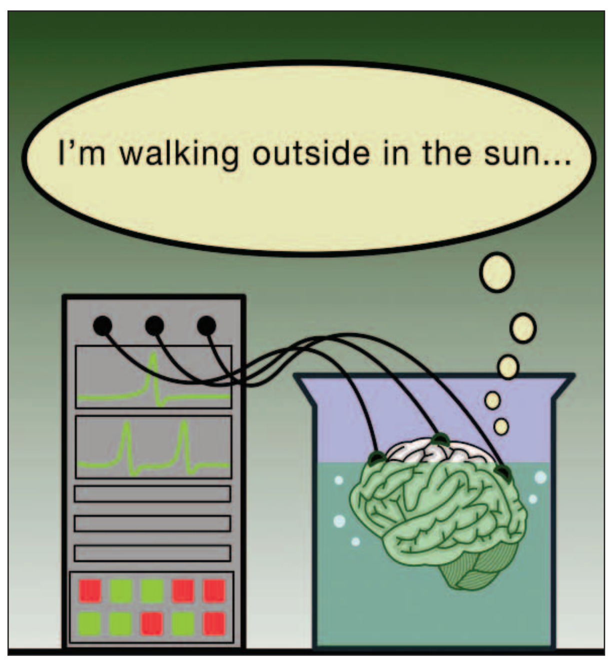

Fig. 6. Diagrammatic representation of the Brain in a Vat thought experiment. (Public Domain. Source: Wikimedia Commons.)

Commensurate with the notion of boundaries and limits and their mobile and enigmatic nature, we again might find interest in taking this notion to its extreme. The extreme of simulation theory is the possibility that what we term reality is in fact itself a simulation—the Simulation Hypothesis, of which the brain in a vat concept is but an encapsulated abstraction [26]. However, for the simulation hypothesis to work, there has to exist an external entity that both devised and, one would suppose, maintains, observes or takes advantage in some way of the simulation. We can transcribe this scenario readily to the laboratory in-vitro situation. The organism, or cell or organic matter that is being grown or cultured, exists in an allegory of the simulation hypothesis. The scientist, artist or lab technician who has set up the culture is the creator and observer of the simulation. The organic matter lives in the virtual, in hyperreality and in a state of transcendental empiricism. If these conditions, illusions and hallucinations were not maintained, then the organism or organic matter would quite simply fail to grow. Its functional circle, as described by Von Uexküll, would be incomplete, and therefore the semiotic system of sign and sign process would cause the organism to fail in the functions necessary to maintain itself [27].

As I read back through my work and consider the notion of simulation and simulation theory in relation to individual projects, I see that it applies across many situations. Once natural material of whatever description has been removed from its original environment, it must be subjected to varying levels of simulation to survive, whether the simulation is simply reproducing the appropriate spectrum of light for a plant or accurately re-creating the flow of nutrients, chemicals and temperatures that allow a cell to persist. Simulation and simulacra are present in the mapping of fish experience to AI (as seen in my project *Fish, Plant, Rack* [28]), in the use of *Drosophila* to study microgravity aboard a space station, in the removal of an organism from nature, in the exposure of microorganisms in culture to space data, and in the growing of imaginal discs. One particular argument remains highly persuasive: that across a vast range of scales, and despite our retreating horizons of knowledge, the biotic aspects of semiosis remain consistent. Simulations, if accurately crafted, are transparent for the purposes of organic function and interrelation. Resulting from this transparency is a manifestation of the discernible interdependence and co-emergence within symbiotic ecosystems, whether they consist of purely natural agents or integrate the artificial.

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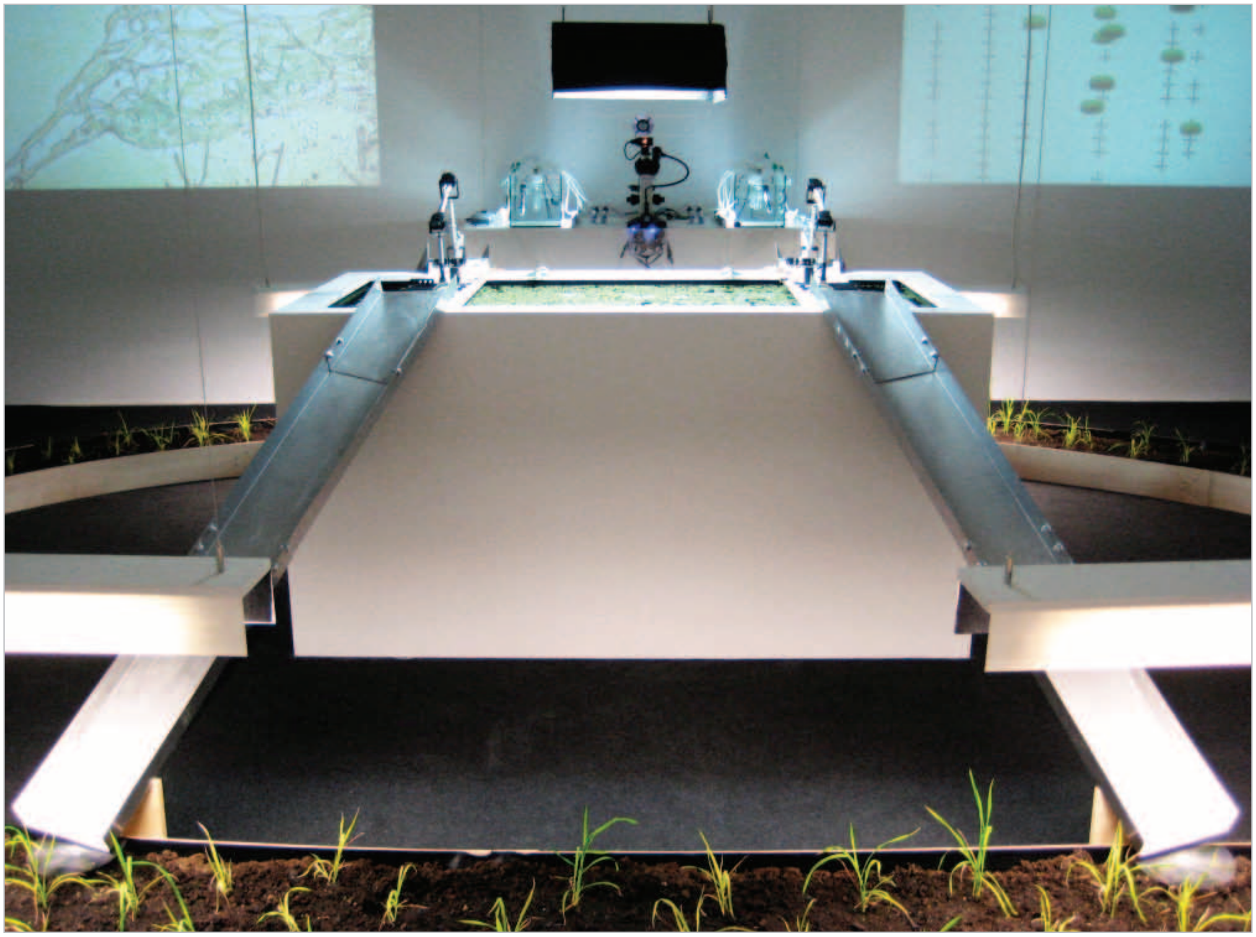
ANDY GRACIE *(b. London, 1967) works across various disciplines, including installation, robotics, sound, video and biological practice. His work is situated between the arts and the sciences and creates situations of exchange between natural and artificial systems that allow newly emergent behaviors to develop. More recently, his work has begun to reflect cultural associations with the science of astrobiology. The underlying focus of his activities has often involved a study of organic intelligence, emergent systems and the placing of technological agents in situations where they are able to share information and behaviors with natural systems and networked ecologies.*

COLOR PLATE A: **ART, SPACE AND HYPERREALITY**



Autoinducer_Ph-1, 2007. (© Andy Gracie)