GENRESIS – TRENDS AND TRAJECTORIES WITHIN THE ART/SCIENCE GENRE

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This panel, conducted at ISEA2014 at Zayed University, Dubai, addressed the influence of scientific developments on art and the emergence of themes within the Art/Science genre. The panelists invited were prominent authors, practitioners and leaders in the Art/Science genre. The panelists responded to a brief, which has been excerpted below:

Recent work presented at Ars Electronica, SIGGRAPH and ISEA propose integrations of art with life-sciences and nanotechnology. Much of this would not be possible without the scientific advances preceding them. In fact, the resulting artwork often critiques the very technology used in their realization. But to what degree does technology determine the emergence of Art/Science themes and movements? Where does art set the precedent? ISEA2010 featured presentations by two major figures in Art/Science research, Roy Ascott and Peter Weibel. Both acknowledged the advance of technology and, particularly, developments in brain research. Weibel proposed that artists might create a non-sensory art generated by electronic brain stimulation. Separately Ascott has long promoted arts/technology/consciousness research and suggested that art can lead the way where science cannot.

The years since have seen considerable developments in the fields of neuroscience and cognitive research. In 2013 the USA's Obama administration announced the creation of the BRAIN Initiative – Brain Research through Advancing Innovative Neurotechnologies. With an initial funding of $100 million the program aims to use emerging technologies to record signals from vast numbers of brain cells and even from entire sections of the brain. This reflects other large neuroscience ventures elsewhere. The European Union's *Human Brain Project* intends to create a computer simulation of the entire brain, drawing a budget of $1.6 billion over a ten-year period. China, Japan and Israel have similarly ambitious neuroscience projects. In a recent article in Scientific American neuroscientist Rafael Yuste and geneticist George Church write, "The global consensus that is now propelling investment in brain science recalls other postwar science and technology initiatives focused on pressing national priorities […] The Century of the Brain is now upon us."

Among current tools for this research are electroencephalography (EEG), functional Magnetic Resonance Imaging (fMRI), emerging nanotechnologies and optical techniques – such as Optogenetics and Optochemistry – that employ light signals to detect patterns in neural firing. The tools used for sensing neural signals can also be used to stimulate the brain discretely. Researchers have employed Optogenetics to "implant" false memories into mice.

If we relate memory to experience and being, then the creation of memories could conceivably lead to a disembodied art form as Weibel suggests. When science leaves consideration of the material world to address emotion, identity and mind it has indeed entered on ground long held by the arts. Here science could learn from art just as art learns from science.

This reciprocity opens up many questions about Art/Science subgenres: How do they emerge? To what degree do they depend on technique, cultural influence or precedent? When are genres defined: by assertion (manifestos), prediction (technological determinism) or when they are recognized in retrospect? What are successful models for collaborations between artists and scientists? How can they negotiate the different processes and methodologies of the disciplines involved? Where are art/sci projects positioned in relation to the mainstream art world?

Peter Anders wrote the brief and moderated the panel. In order of their presentation the panelists included Christiane Paul, Brandon Ballengée, Oron Catts and Paul Thomas. Christiane Paul is an Associate Professor at the School of Media Studies, The New School and Adjunct Curator of New Media Arts at the Whitney Museum of American Art in New York. She is a curator and historian who has written extensively on new media arts. Brandon Ballengée is a Professor at the School of Visual Arts in New York and Visiting Scientist at McGill University. He is an artist, biologist and environmental activist, who creates transdisciplinary artworks – sometimes referred to as Eco-Art – inspired by his ecological field and laboratory research. Oron Catts is the Director of *SymbioticA* - The Centre of Excellence in Biological Arts, School of Anatomy, Physiology and Human Biology at The University of Western Australia in Perth. He is an artist, researcher and curator whose pioneering work with the *Tissue Culture and Art Project,* which he established in 1996, is considered a leading biological art – or Bio-Art – project. Finally, Paul Thomas is an Associate Professor and Program Director of Fine Art at the College of Fine Art, University of New South Wales in Australia. He is an artist and author of the recent book, *Nanoart: The immateriality of art*, which describes innovations in nanotechnology and their application in the arts.

The panelists gave their presentations in person, via the internet and pre-recorded videos. Each spoke for roughly ten minutes and a lively exchange with the audience ensued. Regarding the role biology plays in contemporary art, audience member Diana Domingues observed that art is in fact already an integration of life on many levels. Concerning the challenge posed by the brief Christiane Paul suggested that in fact there may not be a competition between science and art per se. Since art is as imbedded in culture as science, it may be that the two will naturally reflect one another. Audience member Christa Sommerer agreed observing that artists increasingly use scientific methodology in

their research. So it may not be the topic – biology, ecology, neuroscience – that matters so much as changes in artistic practice itself.

The following statements synopsize the panelists' contribution to the Genresis panel.

CHRISTIANE PAUL

A Need for Comprehensive Studies

The evolution of digital technologies, information access, education and social needs, as well as "new media" art since the mid-twentieth century has also brought about a resurgence of interest in art/science (sci-art) collaborations and practice. Art and science intersections and collaborations in fact have a long history spanning centuries. Leonardo da Vinci is often used as the token example in this context, but the story of art and science goes back to cave paintings and artists have explored intersections with science throughout the centuries.

What is missing from the field is a more comprehensive history of trends and trajectories within the art/science genre. This white paper is a call for a more in-depth investigation of these trajectories in the following areas:

1. Histories of Art-Science Practice and its Relationship to the Art World
2. Methodologies & Processes
3. Genres
4. Funding & Support
5. Labs
6. Initiatives
7. Research and Publications

Definitions and Taxonomies

A more comprehensive study needs to make distinctions between roles played by artists and scientists in art-sci practice. Digital / new media art practice by nature implies a fusion art and technology, but one needs to differentiate when it comes to constellations: some artists are "technologists," implementing the technical aspects of their work; other artists are working with technologists who are hired to implement and develop technical aspects of the artists' work. These configurations are different from actual art-science collaborations in which artists and scientists are working on an equal level exploring and fusing the practices in their respective fields.

HISTORIES

1. While there are accounts of art-sci practice in new media, the history of collaborations throughout centuries of artistic practice still needs to be told.
2. The history of corporate support and involvement in art and technology practice at labs such as IBM, Bell Labs and Xerox PARC has received attention, but a more in-depth study of their endeavors and output would be helpful in evaluating the field.
3. Also important would be an account of the relationship between art-science practice and the art world and a comprehensive exhibition history (e.g. the 1986 Venice Biennale was devoted to art and science; exhibitions such as L'Art Biotech, curated by Jens Hauser, at the National Center for Contemporary Arts in Nantes, 2003, are an example of introducing art/science practice to the mainstream art world; a festival such as AxS in Pasadena, CA offers a different type of model for showcasing art and science.)

METHODOLOGIES & PROCESSES

Issues to be explored include: models for collaborations between artists and scientists; methodologies for negotiating the different processes and methodologies of the disciplines involved.
Benefits:
The digital age has the potential to bridge various gaps between art and science. Artistic and scientific technologies of representation both reflect and structure the awareness of the culture in which we are embedded. In the digital age, the technologies of representation as well as concepts in art and science are constantly converging (e.g. mapping of data sets, issues of representation and simulation).
Challenges:
While science – according to its traditional definition – is based on validation of findings, proof and objectivity, art supposedly belongs into the realm of the non-scientific, of speculation, subjectivity, sensual/emotional experience and a freedom of expression beyond accuracy. Stereotypes in art and science need to be overcome to crate a fruitful dialogue.

GENRES

Art-science practice has diversified over the decades and a study of the diversity of practices would be crucial. The field of bio-art alone today includes practices such as:

1. genetic art:
   - transgenics (internalization of synthetic chromosomes)
   - synthesis of artificially produced DNA sequences (as continuation of Mendelian cross breeding of animals and plants)
2. cell and tissue cultures
3. bio-robotics
4. bio-informatics
5. neurophysiology
6. biotechnological and medical self-experimentation

FUNDING & SUPPORT (US)

Another important step in researching art / science collaborations would be an assessment of funding bodies and strategies. The NSF, NIH, DARPA, NEA and other federal agencies and private foundations are now increasingly interested in understanding and funding art/science projects. Trans-disciplinary programs are active in most research universities and recently, STEM (science, technology, engineering and mathematics) education initiatives began to add an A: full STEAM ahead. (Gabriel Harp created a

graph showing the history of grants for projects and programs with art as a strategic focus: http://www.genocarta.com/?p=1139). The NSF-sponsored SEAD Network (Sciences, Engineering, Arts and Design) is a community of advocates who believe that a competitive edge in economic, educational and social wellbeing relies on transformative efforts that span disciplines and domains. SEAD has held conferences (co-hosted by the Smithsonian Institution with some sponsorship by the National Endowment for the Arts) and has drafted white papers.

LABS

Study of the mission, methodologies, outcomes of labs such as

- Nature and Technology Lab (School of Visual Arts, NYC)
- *SymbioticA* (University of Western Australia)
- Art+Science Center and Lab (UCLA)
- ail (artists in labs) (collaboration between the Zurich University of the Arts, ZHdK; Institute for Cultural Studies in the Arts, ICS; and the Federal Office for Culture, FOC)

INITIATIVES

Study of the mission, methodologies, outcomes of initiatives such as

- ASCI (art & Science Collaborations Inc.)
- SARC (Scientists/Artists Research Collaborations) at the Santa-Fe based 1st-Mile Institute
- SYNERGY - affiliation with Massachusetts Institute of Technology (MIT) and Woods Hole Oceanographic Institution (WHOI)
- SETI Institute Artist in Residence Center
- ART+BIO Collaborative - non-profit organization, affiliated with MassArt Boston)

RESEARCH AND PUBLICATIONS

Bibliography of research and publications such as Leonardo (MIT Press) and SciArt in America (New York).

BRANDON BALLENGÉE

Ecological Understanding through Trans-disciplinary Art and Participatory Biology

Today's environmental issues are often complex and large-scale. Finding effective strategies that encourage public awareness and stewardship is paramount for long-term conservation of species and ecosystems. Artists and biologists tend to stay confined within their professional boundaries, their discourses largely inaccessible to larger audiences. I will propose arguments for a combined approach, which disseminates knowledge about ecology to non-specialists through novel art-science participatory research and exhibitions. Historically scientists have used creative art forms to disseminate scientific insights to a larger populace of non-specialists. Such strategies as compelling texts and visually provocative artworks may still be effective in captivating contemporary audiences. In addition such historic hybrid science-art practitioners may have laid a conceptual terrain for some of today's trans-disciplinary art and citizen science practices. Seminal ecological artworks from the 20th Century by Joseph Beuys, Patricia Johanson and Hans Haacke employed novel strategies to reach audiences with a message of conservation, blurring boundaries between art, ecology and activism. More recently artists like Cornelia Hesse-Honegger, Helen and Newton Harrison and others have integrated biological research into their art practices, which in turn resulted in new scientific discoveries. Through my own trans-disciplinary artwork concerning frogs, data suggests that the visual strategies I employ effectively increased non-specialist understanding of the ecological phenomenon of amphibian declines and deformations.

In addition evidence from my participatory biology programs, Public Bio-Art Laboratories and Eco-Actions, suggests that non-specialists can achieve an increased awareness of the challenges now faced by amphibians and their ecosystems. Likewise, through participatory citizen science research new scientific insights were achieved regarding proximate causes for deformities in anuran amphibians at select localities in middle England and Quebec. Here laboratory and field evidence, generated with the aid of public volunteers, found that non-lethal predatory injury to tadpoles from odonate nymphs and some fishes resulted in permanent limb deformities in post-metamorphic anurans. From an environmental-education and larger conservation standpoint, these findings are very relevant as they offer novel strategies for engaging non-specialist audiences while generating important insights into biological communities and wetland ecosystems.

ORON CATTS

Why Artists Seriously Play With Life?

Humans' relationship with the idea of life is going through some radical shifts; from the sub-molecular to the planetary. The cultural understanding of what life is and what we are doing to it lags behind the actualities of scientific and engineering processes. From Synthetic Biology and Regenerative Medicine, through Neuro-engineering and Soft Robots to Geo-engineering, life becomes a technology, a raw material waiting to be engineered. This provides a new pallet for artistic expression in which life is both the subject and object. In the fields of science and engineering, radical approaches to life – driven by mindsets of control – seem to be taken haphazardly. This exposes unintentional ontological breaches and reveals an urgent need for cultural, artistic scrutiny of life. This scrutiny is beyond human speculation and through direct and experiential engagement.

Artists dealing with the theory, practice, application and implications of the life sciences help create a platform that actively pursues different directions in which knowledge and technology can be applied. This can be seen as cultural scrutiny in action, articulating and subverting the ever-changing relations with life. Much of the work of biological artists seems to be transgressive, trespassing into areas where "art should not go." Yet it often does little more than culturally frame the manipulations

of life that have become commonplace in the scientific laboratory. This aesthetically driven and confrontational treatment of life by artists can create an uneasy feeling about the levels of manipulation applied to living systems. This uneasiness seems to stem from current values and belief systems that seem ill-prepared for the consequences of applied knowledge in the life sciences. Life is going through a major transformation, even if it seems more perceptual than actual. Through rigorous, critical and indeed wondrous explorations in the life science laboratory, the artists begin a dialogue, engaging with the extraordinary potentials and pitfalls of our new approaches to life.

SymbioticA is recognized as the first artistic laboratory dedicated to providing artists with support for this kind of research within an institutional setting. It is acknowledged as a benchmark for similar labs. The laboratory was established in 2000 within the School of Anatomy, Physiology and Human Biology at The University of Western Australia. *SymbioticA* specializes in Biological Arts, developing programs such as artistic research residencies, workshops, academic courses and public engagement through exhibitions and public presentations. To date, *SymbioticA* had more than eighty artist-researchers that were mentored to develop skills and make use of scientific techniques in manipulating life forms. Some examples of past residents are ORLAN, Critical Art Ensemble, Kira O'Reilly, Chris Salter, Peta Clancy and Helen Pynor. Through their hands-on experience, these artists become deeply engrossed in scientific methodologies and technologies. As a consequence, their projects may intentionally provoke, expose hypocrisies, meditate upon and question the limits of 'what is acceptable' by current societal standards.

Being based within a research university, *SymbioticA* needs to adhere to regulations concerning ethical conduct and health and safety. In most cases our research is scrutinized much more strictly than our scientific colleagues' work. A common criticism of the work undertaken by artists in residence is that this type of artistic involvement with life is frivolous and in some cases "shocking." The apparent lack of utilitarian value seems to trigger such reactions but at the same time it does what art does best – create awareness and allows critical engagement that destabilizes perceived assumptions and challenge perceptions.

PAUL THOMAS

Materiality and the Evolution of Graphite

This paper explores the speculative nature of the quantum universe. Marcel Duchamp in 1913, eight years after Einstein's theory of relativity and fourteen years before Werner Heisenberg's Uncertainty Principle, demonstrated poetically the problem of measurement in his work *Three Standard Stoppages*. To explain this problem of measurement in quantum mechanics I refer to Karen Barad: On the face of it, these questions seem vacuous, but there may be more here than meets the eye. Consider, first, setting up the condition for the experiment: we begin with a vacuum. Now, if a vacuum is the absence of everything, of all matter, how can we be sure that we have nothing at hand? We'll need to do a measurement to confirm this. We could shine a flashlight on the vacuum or use some other probe, but that would introduce at least one photon (quantum of light) onto the scene, thereby destroying the very conditions we seek. Like turning up the light to see the darkness, this situation is reminiscent of the mutually exclusive conditions of im/possibility that are at issue in Niels Bohr's interpretation of quantum physics. [1]

This paper will describe the historical moment of new materiality in which we live by examining the humble graphite pencil and the implications inherent in the discovery of graphene. To explore this moment we examine the tool of the pencil and its medium graphite to provoke discussion on our understanding of the material world and our relation to it. To draw with a pencil is shape one's thought spatially and diagrammatically in ways no other medium can express. Drawing helps us to render, comprehend and make sense of the structures and laws that bind our world. The art of drawing, then, is a discursive act in which the pencil mediates thought, capturing reality in the act of happening. The major focus of this paper is the development of graphene in 2004, which – prior to this time – was purely theoretical, a single sheet of carbon atoms. The process through which this material was extracted was a simple laboratory experiment: using scotch tape to whittle down graphite to a single sheet of graphene. There are a many assumptions that one can draw upon when looking at a pencil, but it is at a moment in 2004 when these assumptions were tested and new territories appeared on the horizon. Now the pencil's constituent, graphene, has taken on surreal new forms that were inconceivable prior to 2004. We need to be aware of the pencil's genealogy. It will be people such as you who will demonstrate how the discovery in 2004 brings the material's agency into new territories.

Graphite for pencils came to being around 1500 when large rare deposits were discovered at Barrowdale in the UK. The pencil with a wooden sleeve, developed in 1560, gave impermanency to the mark for artists and writers. It was used to make the imperceptible real, to communicate ideas. The material graphite/graphene now takes on a new role in communication technologies, nanotubes, quantum computers. The Graphene Moment is evidenced by what would appear to be historically ridiculous concepts, now made real. The transformation of this material calls for the reevaluation of graphite's capabilities. Questions related to an artistic interpretation of the world via graphite now challenge the quantitative approach of science. The discovery of graphene enables us to explore new material developments and research within the domain of drawing. The articulation and mapping of understanding establish graphite and the pencil at a focal point in time. Richard Feynman's pencil diagrams, graphene, nanotubes and the mechanic atomic force microscope (AFM) contribute to an analogous history of drawing. Science and technological research via the AFM's pencil-like probe is of particular interest here.

AFM

A fundamental change in our understanding of materiality has evolved through a quantifiable 'machinic' comprehension of the world. The instruments of nanotechnology change the visualization of matter. We now see a world made visible by tools of nanotechnology such as the Scanning Tunneling Microscope (STM) in 1981 and the later Atomic Force Microscope (AFM) in 1986. The AFM is one of the foremost tools for imaging, measuring and manipulating matter. Gathering scientific data through touch challenges a dominant ocular-centric understanding of the world. The AFM and nano-assembly allow us to move atoms and create new materials, forms and structures. They replicate the biblical construction of humans from dust particles.

The discovery of graphene makes us rethink the way we view the world and, therefore, the way we represent the world. Graphene, which is the name for a single atomic sheet of graphite (a pure form of Carbon), is an excellent conductor of electricity and is fit for various mechanical purposes. Since its discovery in 2004 graphene, 200 times stronger than steel, has been applied to many new purposes – from the construction of next-generation transistors to light-weight, high-strength composite materials, from flexible television screens to quantum computing. Graphite is being explored across many university research centers. Of these the Centre for Quantum Computation (CQC) at the University of Oxford, led by Dr. Simon Benjamin in the area of Molecular & Solid-State, is of particular note.

Thus, one possible building block of the quantum computer is the buckyball C60. The C60 molecules have individual nitrogen atoms fired at them that become trapped inside the buckyball, creating nC60 molecule, which is at the very core of a microprocessor's array. The caged nitrogen atom within the buckyball is incarcerated and isolated but still has the ability to spin and can be controlled by microwaves to emulate the zeros (by spinning up) and ones (by spinning down) of the digital computer's binary code. However, quantum computing explores the potential of the nitrogen atom's superposition inside the buckyball to be in more than one state (not zero or one) at the same time. [2]

We now face the implications that the discovery of graphene has on the medium of drawing. A range of contemporary artists has taken up a revised approach to the materiality of graphite. This shift in the potential or perceived agency of the material of graphite has opened up a rich new environment for creativity and inter-disciplinarity.

The Art of Graphite

The challenge to our understanding of materiality of graphene is played out in Victoria Vesna's and James Gimzewski's 2002 artwork, *Zerowave Functions.* The work takes the viewer inside the imaginary, enabling them to draw and shape molecules with their own shadows. The exploration of graphene will be put to use in Benjamin's quantum computing research and demonstrates the development of immaterial relationships while engaging in the possibilities of thinking particles. The user inadvertently draws the buckyball across the surface and engages with it through the gesture of transferring meaning through the act of mark-making. The interaction with the C60 molecule suggests complex relationships with matter, playfully controlled by the viewer. At the same time it opens up questions of manipulation – even colonization – of the material world. The revelation of graphene has great consequences for the practice and epistemology of drawing. The art historical importance of the emergence of graphite is in the how, why and what of radical reinvigoration of the medium. The human body's major ingredients, Carbon (18%) and Oxygen (65%), draw interesting parallels with the pencil and suggest shared alchemical genealogy. What could we make of the relationship between chemical components of material graphite and that of the human body? Do we start to see these attributes as being causal, intrinsically linked to being human? What are the connections between a conscious state for matter when applied to a material that makes the invisible world visible? Synergies converge around thinking as being atomic: the use or carbon atoms in the processing power of the quantum computer; the potential of graphene as a telecommunication tool. These speculations demand rethinking the marks we have made. The ability of the material to express human thought is much more powerful than we could have initially imagined. Graphite may now serve not only to record and map thoughts but now inscribe a range of non-semiotic utilities, such as its aptitude as conductor of electromagnetic currents.

The transforming agency of graphite and the definition for new modalities of drawing are central to graphene as a material in the production of contemporary monitors and touch screens are of great significance. The confluent material agency of graphite as tool for visualizing the world both physically and, now, digitally announces a new kind of drawing. The same material that has historically been used by artists is now central to mainstream digital media of communication today. The reestablishment of touch as the sense connecting us directly with the material world is implicit in our transmissions through the pencil to the surface of the paper. As though the old gramophone needle that draws out the undulations of the record and translate it into sound could by a similar process of reengineering of information exhumed from the pencil marks. The inauguration of graphene has prompted the need for revisionary history and reconceptualization of graphite drawing. These new interpretations of old materials show the need to expand sensory awareness of our surroundings, how we interrelate and interact in it.

We have covered the relationship between graphite and graphene to discover something about the 'agential' relationship that is applied to materials. Once we perceive what was at first invisible and also inconceivable, the complex understandings of our material world shift. We comprehend that thinking and thoughts are atomic and stem from an intuitive understanding of rationalizing

nothing. In other words, if nothing cannot exist and everything is something and the smallest individual part is atomic and as thoughts are something they must also be atomic. The writings of the Epicurean Lucretius in his poem '*On the Nature of Things'* led to the swerve as being at the heart of all classical matter. The swerve and or spin of the photon, electron and nucleus are also at the heart of quantum computing placing the genealogy of thought as thought itself. Thinking the world into existence becomes part of the process as humanity attempts to understand the universe and our role within it. Thinking machines generated by the same atoms as their creators demonstrate what we already intuitively understand.

How can art express in a new voice, a new language that creates an awareness of its role in the development and influence of thinking about the nature of our world? The discovery of graphene shows us that this is not the only way to think of nature. Gavin Parkinson situates this argument historically and culturally with reference to surrealists in the 1930's where he discusses "the peculiar difficulties faced by artists in finding a language for the 'new reality' revealed by the physicists and argues that the relocation of Surrealism in a discursive field which includes quantum physics discloses the rationale behind its artists' shift to a semi-abstract language." [3] This statement reveals a link with the illuminations gained from probing and constructing realities in the same moment that science is exploring its constructed realities, drawing out synergies in the age of art, science and technology.

The Euclidian gaze of a measured universe where that viewpoint puts each individual at its very center creates the schism that can't be breeched by new terminologies. The shift that needs to take place follows on from a pursuit of 20th century art in reconfiguring the perspectival gaze. It allows us to re-connect, to become part of the material world, not merely voyeurs. This cannot be stressed enough in terms of sensing space. Thinking of pre-perspectival space as a garment that one wears changes our understanding of what our relationship with the material world can be.

FOR THOMAS' PRESENTATION:

7. Barad, K. (2012). Karen Barad: what is the measure of nothingness? Infinity, Virtuality, Justice.
8. Documenta (13): The Book of Books, 100 Notes, 100 Thoughts. Ostfildern: Hatje Cantz.
9. Parkinson, G. (2004). "Surrealism and Quantum Mechanics: Dispersal and Fragmentation in Art, Life and Physics." Science in Context 17(4): 20.

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