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Nanoessence: God, the first nano assembler

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Abstract

The Nanoessence project aims to examine life at a sub-cellular level, re-examining space and scale within the human context. A single HaCat skin cell is analysed with an Atomic Force Microscope (AFM) to explore comparisons between, life and death at a nano level. The humanistic discourse concerning life is now being challenged by nanotechnological research that brings into question the concepts of what constitutes living. The Nanoessence project research is based on data gathered as part of a residency at SymbioticA, Centre of Excellence in Biological Arts, University of Western Australia and the Nanochemistry Research Institute, (NRI) Curtin University of Technology. The space of the body can be seen at an atomic level as having no defining boundaries. More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognition in particular, to cause single-molecule components to automatically arrange themselves into some useful conformation (reference Wikipedia). Nano assembly, or 'bottom-up' approach, is the construction of a supramolecular chemistry by the assembly of nanoscopic particles, or even atoms and molecules. The proposal for nanotechnology to reshape nature atom by atom develops an interesting debate as to the constitution of life. The Nanoessence project aims to construct a physical experience to examine this scientific and metaphysical world. Nanoessence is an interactive audio-visual installation. In the Nanoessence installation the viewer will interface with the visual and sonic presentation through his or her own breath. In the context of the project breath has a strong conceptual and metaphorical link to a Biblical inception of life. The project attempts to maintain a high quality of authentic data to engage the viewer in a sensorial qualitative experience of quantitative data.

Keywords

art
biology
life
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science
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Aims

The Nanoessence project aims to examine life at a sub-cellular level, re-examining space and scale within the human context. A single HaCat[1] skin cell is analysed with an Atomic Force Microscope (AFM) to explore comparisons between, life and death at a nano level. The humanistic discourse concerning life is now being challenged by nanotechnological research that brings into question the concepts of what constitutes living.

The project maintains the difference between science and art by accepting difference in rhetoric used in describing each various sets of conditions. The difference between quantitative text that illustrates scientific

1. The apparently immortalized but highly differentiated cell line was named HaCaT to indicate the origin and initial growth conditions (Boukamp et al. 1988).

research and art that expresses assumptions in a substantive qualitative text.

Henri Bergson laid the basis for such a discourse at the turn of the century in Matter and Memory where he stated that the link between the machinic (measured movement) and the sensory are

> two different worlds, incapable of communicating otherwise than by a miracle – on the one hand, that of motion in space, on the other hand, that of consciousness with sensations …. Between quality on the one hand and pure quantity on the other.
>
> (Bergson 1996: 202)

The space of the body can be seen at an atomic level as having no defining boundaries. More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognition in particular, to cause single-molecule components to automatically arrange themselves into some useful conformation (reference Wikipedia). Nano assembly, or 'bottom-up' approach, is the construction of a supramolecular chemistry by the assembly of nanoscopic particles, or even atoms and molecules. The proposal for nanotechnology to reshape nature atom by atom develops an interesting debate as to the constitution of life. The Nanoessence project aims to construct a physical experience to examine this scientific and metaphysical world.

Nanoessence is an interactive audio-visual installation where the viewer will interface with the visual and sonic presentation through his or her own breath. Breath plays a quintessential role conceptually with its strong metaphorical link to a biblical inception of life.

The Nanoessence project explores and utilizes in the installation the scientific data produced from the experimental scanning of a HaCat cell. The project attempts to maintain a high degree of authenticity in using data created directly from the AFM's recordings to engage the viewer in a sensorial qualitative experience of quantitative data pertaining to life.

Nanoessence premise

In this section the interconnected relationships between the HaCat cell, the AFM and the breath interface that together constitute the Nanoessence project will be examined.

The cells chosen for use in the Nanoessence project are HaCaT cells, which 'although immortal, have largely retained their capacity to reconstitute a well structured epidermis after transplantation in vivo' (Nykypanchuk et al. 2008: 770).

The HaCat like other cells have an engineered immortality and therefore demonstrate the potential of endless cloning of a single cell. 'Thus, HaCaT is the first permanent epithelial cell line from adult human skin that exhibits normal differentiation and provides a promising tool for studying regulation of keratinization in human cells' (Boukamp et al. 1988).

The creation of immortality was usually the prerogative of gods and not humans. The development of an immortal living cell line has a relationship with the creation of life in Genesis. The tree of life was planted by God in midst of the Garden of Eden (Paradise), where the fruit bestow everlasting

life and immortality to the person who eats it. The potential here is to see that when life was being bestowed to humans, they were then given the opportunity for immortality. The opportunity for immortality was lost due to a moral failure, whereas now scientific cellular immortality can be constructed in a Petri dish.

The AFM constructs a machinic understanding of a material's nano particles through touch. The AFM works as a contradiction to traditional microscopes by privileging the sense of touch over sight, reintroducing a sensorial-machinic focus of perceiving the world.

The AFM, invented in 1986, was developed at the end of a long line of optical microscopes first introduced in the early 1600s. Robert Hooke (1635–1703) used the optical microscope to study living systems.[2] Optical microscopes were used exclusively until 1931 when the first Electron Microscope was introduced. The Scanning Probe Microscope (SPM) is a general category that includes both, the Scanning Tunnelling Microscope (STM) introduced in 1981 and the Atomic Force Microscope (AFM).

Optical microscopes have a number of limitations in that they can only image dark or strongly refracting objects effectively. The diffraction limits resolution to approximately 0.2 micrometre and ambient light can diffuse the focus. Unlike the previous microscopes, the AFM is not optical and therefore the name is a misnomer. The AFM uses a cantilever probe to touch the surface reverting to a scanning process where an image of the surface is obtained by mechanically moving the probe in a raster scan of the specimen, line by line, and recording the probe–surface interaction via a laser being reflected on a photodiode.

The AFM uses a small cantilever whose pyramid-shaped tips measures approximately 10nm that is slowly lowered onto the surface of a sample. The sample is then scanned with the cantilever tip recording the atomic surface and the data is recorded via a laser beamed onto the top of the cantilever tip which is then reflected onto a photodiode. The concept of gathering scientific data through touch allows for a reconfiguration of a dominant ocular centric understanding of the world. The AFM and nano assembly display the potential to move atoms around to create new materials, forms and structures replicating the construction of man from dust particles.

The rationale for the use of breath as the interface for the Nanoessence project is contextualized through the reading of Genesis 2: 7. In this section of the bible, dust particles are gathered together by God to create man. God then having created a lifeless shape transmitted the breath of life into man's nostrils (2: 7). And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul.[3] The act of transmitting life is relative in this context as it suggests that life cannot be manufactured but needs to be transmitted. The haptic quality of breath as a material construct amplifies a sense of touch at a nano level. The breath acts as a paradox of transmission between the material and immaterial, touching upon properties of posthumanism as opposed to being human.

In the Qu'ran it is stated that 'He directed Himself to the heaven, and it was a vapor, so He said to it and to the earth: "Come both of you, willingly or unwillingly." They both said: "We come willingly."' (41. 11)[4]

2. It was Robert Hooke (1665) who published 'Micrographia' where he coined the term 'cell'. When looking through the microscope at box like cells of cork he was reminded of a monk's cell in a monastery.

3. http://king-james-bible.classic-literature.co.uk/genesis/ebook-page-02.asp

4. http://www.al-islam.org/inquiries/4.html

Mohamad Jawad Chirri stated in an online interview with Wilson H. Guertin when speaking about this extract from the Qu'ran that '(T)he quoted verse indicates that the vapor or what constitutes the vapor of molecules and atoms was the first material thing that existed in this world'. Pedro C. Marijuán in his paper 'Bionformation: untangling the networks of life' suggest that 'Water is the starting point. Necessarily, it has to be considered the first biomolecule, the primordial one which has "selected" all the other molecules participating in the evolutionary plays of life'.[5]

5. Pedro C. Marijuán references Lima-de-Faria (1988, 1995).

In Nanoessence the HaCat cell, the AFM and breath demonstrate a fundamental symbiotic relationship in the instigation of life at a nano level. The dust particles, vapour and breath are fundamental concepts and materials utilized in the Nanoessence installation's investigation of the creation of life. The Nanoessence project uses the data from the AFM to look at various aspects of revealing differences at a nano level in topographical visualizations and sonic structures between life and death.

Biology to nano

The Nanoessence project research is based on data gathered as part of a residency at SymbioticA, Centre of Excellence in Biological Arts, University of Western Australia and the Nanochemistry Research Institute, (NRI) Curtin University of Technology.

Figure 1: Extracellular matrix being filtered into before being added to the substrates.

HaCat skin cells cultured with the assistance of SymbioticA were scanned by the AFM in tapping and force spectroscopy mode to determine comparative topographies and atomic vibration as the cantilever tip scans the cell.

HaCat cells are

> (F)ull thickness adult human body skin was obtained by surgical excision, in the case of HaCaT from the distant periphery of a melanoma located on the upper half of the back (not extensively sun-exposed) of a 62-yr-old male patient. The histology of the epidermis from the skin specimen obtained in a second, 'safety operation at the primary melanoma site showed no apparent anomalies'.
>
> (Boukamp et al. 1988: 761)

The Nanoessence research commenced on 7 January–11 January 2008 at SymbioticA. New mica substrates that were scaled to fit the AFM scanning Petri dish were sterilized. The sterilized substrates were given a coating of collagen (extracellular matrix) that provides structural support so that the skin cells can attach more securely to the surface of the mica. The samples coated with extracellular matrix (collagen) were put into the incubator for one hour so the collagen could cross-link with the mica. The excess collagen was then washed away, ready for the samples to receive the cells.

Figure 2: The mica substrate is placed on holder to be inserted into the AFM. The rubber circlip is placed under AFM polystyrene Petri dish. The Petri dish is being assembled before the serum is placed back over the cells.

The cells were then extracted from the tissue culture flask by first removing the nutrient solution (which contained serum) and then using trypsin, which is a digestive enzyme that causes the cells to detach themselves from the surface on which they are growing. The cells were then added to the mica samples and placed in a 37C/5%CO2 incubator. Within two days the cells were confluent on the six mica substrates and ready to be transported to the Nano Research Institute at Curtin University.

The two mica samples were collected from SymbioticA on 14 January at 10 a.m. and placed in a transportable incubator. The living HaCat skin cells were unpacked from the transportable incubator at 11 a.m. at the NRI and one mica substrate sample was placed under a watertight container (Figure 3) to be filled with serum and then inserted into the AFM. The AFM was set up in tapping mode and initial scanning commenced at 11.30 a.m.

The living HaCat skin cell is raster scanned by the AFM in tapping mode. A piezoelectric actuator is used to control the height of the cantilever as it scans above the skin cell using the AFM in tapping mode

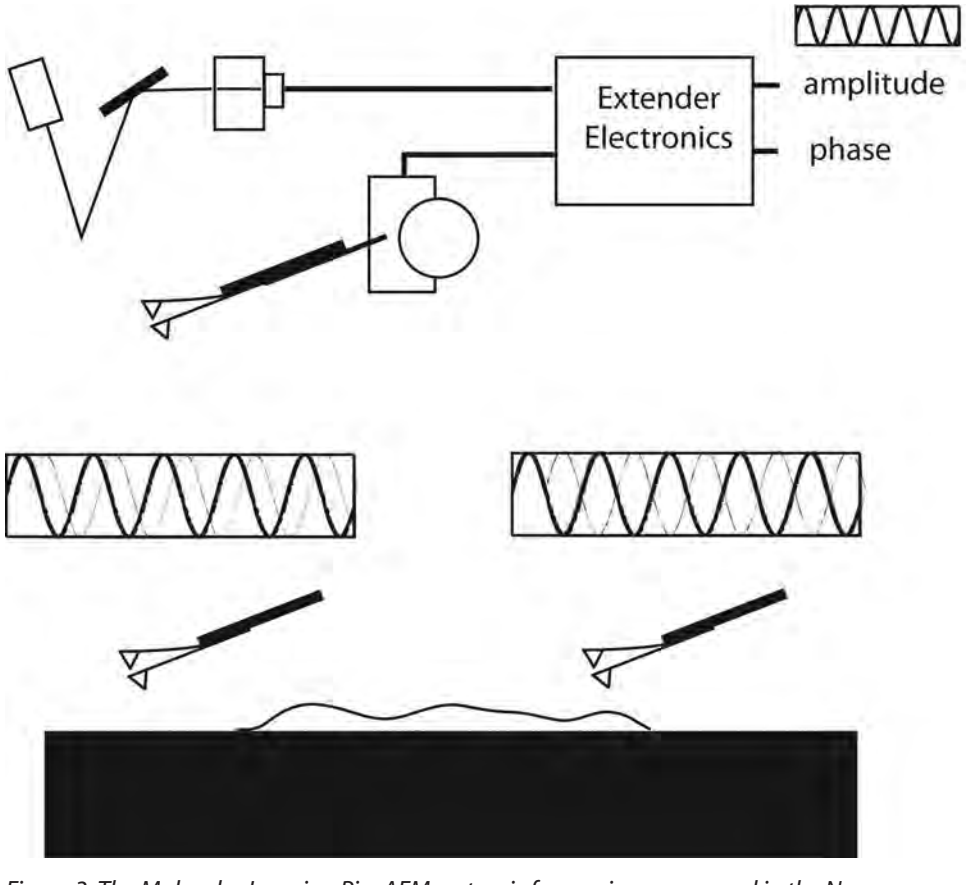

Figure 3: The Molecular Imaging PicoAFM – atomic force microscope used in the Nanoessence project used phase imaging to represent the HaCat cell.

where the cantilever makes intermittent contact as it is lowered to almost touch the surface of the skin cell. In tapping mode the cantilever oscillates up and down in literally a tapping motion created by a resonance frequency.

The oscillations creating the tapping motion are between 100 nm and 200 nm so the space between the surface and the cantilever is infinitesimal. An area of the specimen measuring 30 x 30 microns was scanned and the images obtained from the cantilever's motions were recorded via the laser beam deflection from the cantilever tip onto the photodiode (Figure 3). A more sensitive recording is carried out in tapping mode so as not to damage the cell structures. The AFM cantilever explores the surface topographies gathering data to produce various formats, topography, friction, phase, deflection and amplitude to create the images.

> Phase Imaging is a powerful extension of TappingMode™ Atomic Force Microscopy (AFM) that provides nanometer-scale information about surface structure and properties often not revealed by other SPM techniques. By mapping the phase of the cantilever oscillation during the TappingMode scan, phase imaging goes beyond simple topographical mapping to detect variations in composition, adhesion, friction, viscoelasticity, and numerous other properties.

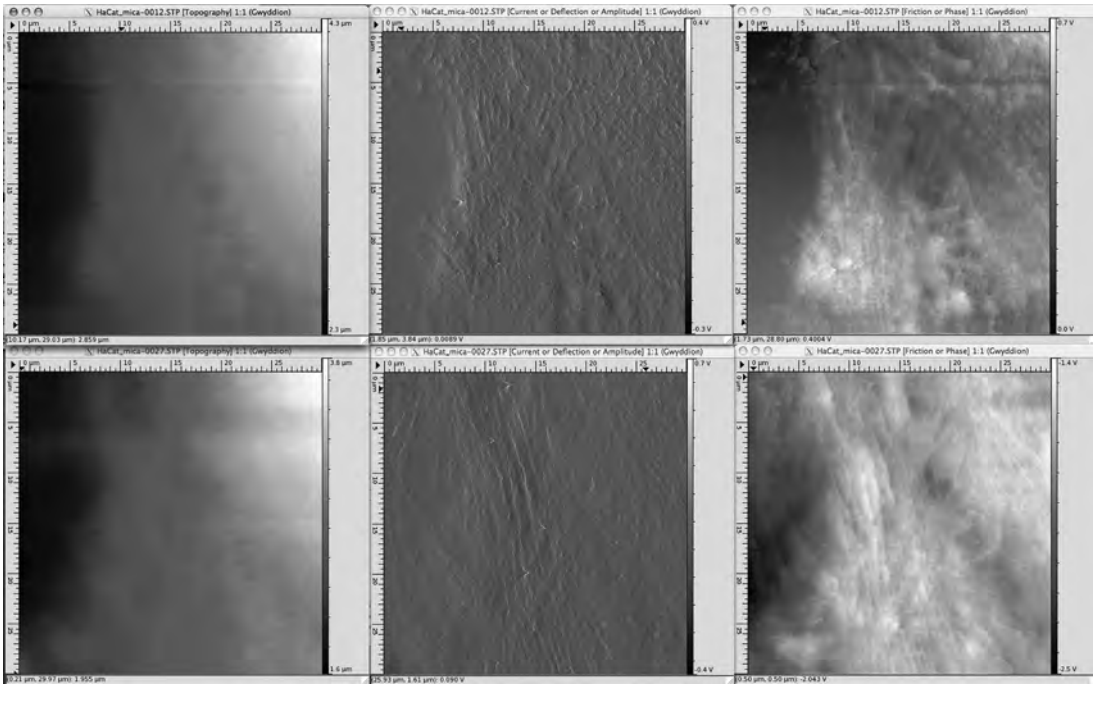

Figure 4: Image shows three modes of image representation from the AFM data. (Left) topography, (middle) deflection or amplitude, (right) friction or phase using Gwyddion software. The images represent scan of living HaCat cell (top row) and scan of a dead HaCat cell (bottom row). The cells were scanned for a duration of 2 hour period.

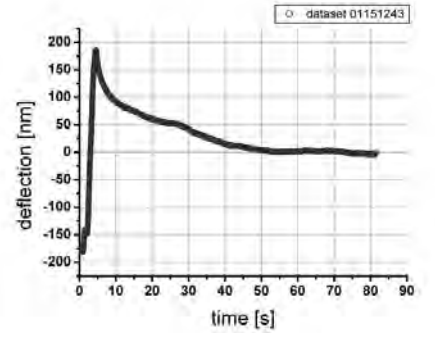

Figure 5: AFM force spectroscopy reading of a living cell.

> Both the TappingMode topography and phase images are viewed side-by-side in real time. The resolution of phase imaging is comparable to the full resolution of TappingMode AFM. Phase imaging can also act as a real-time contrast enhancement technique.

The initial set of experiments was repeated under the same conditions the next day with a scale adjustment, reduced down to 2.5 x 2.5 microns from the first day's scanning. The scans were also produced over two hours allowing for the HaCat cell to expire.

During the second day we also used another AFM in the NRI, this time in force spectroscopy mode. The force spectroscopy mode does not scan the surface of the cell but determines the atomic vibration as the tip touches and then rests on the surface of the cell.

Data to ascertain the reaction of ether to a group of atoms of the HaCat cell was gathered by using the AFM in force spectroscopy mode. The living skin cell was initially sampled *in vitro* by the AFM in force spectroscopy mode. The data of the atomic vibration was recorded via the AFM for a period of five seconds. The serum immersing the skin cell was injected with ether whilst the scanning process was taking place and the cell was recorded for a further five seconds.

In Figure 5 the diagrams show the cantilever travelling to the living HaCat cell where it makes contact and then slowly rests on the surface of the cell. In Figure 6 the diagram shows the dead HaCat cell resists the cantilever that demonstrates a change in the surface layer.

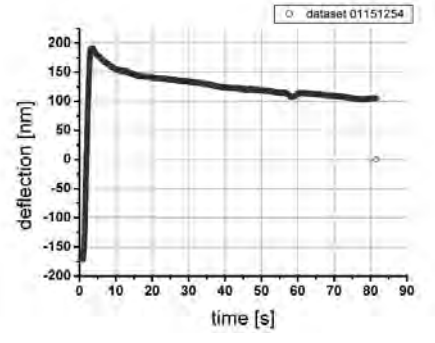

Figure 6: AFM force spectroscopy reading of a dead cell.

The data from both these experiments was taken to Dr Peter Hinterdorfer Associate Professor, Institute for Biophysics, Johannes Kepler University of Linz. This meeting was to discuss the scientific reading of my practical research in the Nano Research Institute at Curtin University of Technology. Hinterdorfer examined the data and suggested that the skin cell whilst being recorded in phase mode, the head of the cantilever is tapping and makes contact to the skin recording the attraction and resistance. Hinterdorfer pointed out how in the original experiments the surface of the skin cell had shrunk and tightened revealing the internal structural scaffolding and lines of communication within the cell. The visual images recorded in phase mode revealed the HaCat cell's structural supports that carry the information throughout the cell.

Nanoessence installation

The Nanoessence project attempts to define some of the issues relating to the creation of life through the construction of the installation and interface. The role of the artwork is to define and bring together some of the discussions being processed through a posthumanist discourse.

In Nanoessence the viewers will breathe into a small sculptural reconstruction of the nasial passages where sensors are positioned to register the strength and the moisture content. This data from the breath and its vapour will be used to generate genetic algorithmically constructed cellular automaton code.

The nasial structure that the viewer will blow into is a rapid prototype reconstruction of the three-dimensional internal geometry of the human upper airway captured by the Curtin University of Technology Engineering Faculty. The human upper airway was recorded using a catheter-mounted anatomical optical coherence tomography (*a*OCT).[6] The three-dimensional computer model will be modified to allow for the sensors to be embedded

6. The (*a*OCT) 'directs a light beam perpendicular to the catheter-distance between the probe head and the air–tissue interface of the airway wall is determined from the reflected light using a low-coherence optical interferometer. Probe rotates at 1.25 Hz to capture quantitative cross-sectional images of the upper airway' (Wang et al. 2006).

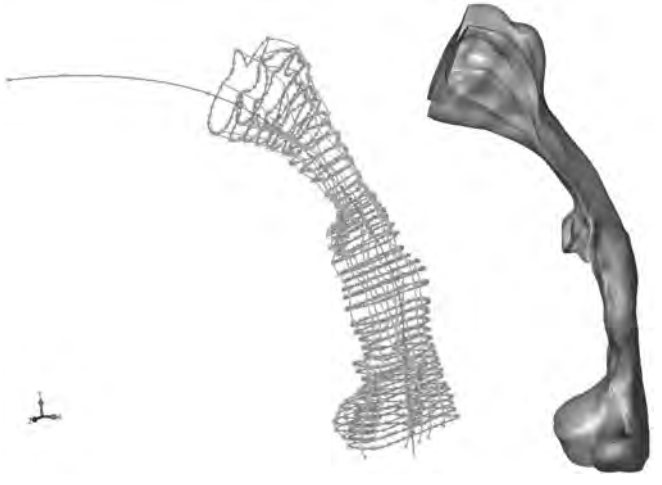

Figure 7: Lucey, A.D., Armstrong, J.J., Leigh, M.S., Paduch, A., Sampson, D.D, Walsh, J.H., Eastwood, P.R., Hillman, D.R., Harrison, S., 2006. Dynamics of the human upper airway: On the development of a three-dimensional computational model. In IFMBE Proceedings 14 (World Congress on Medical Physics and Biomechanical Engineering, 27th August–1st September 2006) *ISSN 1727-1983, ISBN 3-540-36839-6 (4 pages).*

seamlessly into this structure. The breath and moisture sensors will create a reading to infect, affect and stimulate the growth patterns of the projected metaphorical cell landscape, establishing the parameters for the essence of life to evolve.

A hybrid metaphorical landscape is created from the comparative data of the living and dead cell recorded by the AFM of the HaCat cell. The comparative data can be seen as representing the essence of life and creates the basis for the construction of a hybrid metaphorical landscape. The hybrid metaphorical landscape will emerge from an algorithm developed by Kevin Raxworthy based on cellular automaton. The algorithm is affected and stimulated by using the different information gained from the sensors via the user's breath. Each breath and moisture reading will create and stimulate the parameters for the essence of life to grow.

Three large data projections display topographies of skin cells at a nano level. The left projection is of a living cell and the right is of a dead cell. The central image will represent an emerging transforming topography that evolves from the comparative data difference recorded in the space between living and dead, the essence of life.

The sonic topographic texture of Nanoessence is created from analysis of data recorded from the AFM in force spectroscopy mode. The vibrations of the HaCat cell atoms are scanned initially *in vitro* and then a second time with ether injected into the serum. The resulting comparative analysis of the data is converted into sound files. The installation presents the auditory work consisting of sonic vibrations that occur at the nano level and will also be presented to the audience as a spatially orientated haptic topographic sensation. The auditory work will sonically map out a topographical relationship to the changing landscape.

The aim of Nanoessence is to promote other senses in the understanding of infinite smallness as well as creating a psychological shift in the viewer using breath as an interfacial device that initially re-orientates the viewer to identify both sonic and visual differences between a living and dead single skin cell.

Figure 8: AFM in tapping mode phase image of a HaCat cell in 3D.

Nano futures

Henri Bergson dealt with concepts of duration that when brought to focus on matter recognized 'elementary vibrations' (1911: 212) where matter almost vanishes. Bergson suggested the more 'duration' seen as vibrating matter became part of our consciousness, the more 'different parts of our being enter into each other' (1911: 212). These remarks relate to the very core of the Futurists artist Umberto Boccioni's works of 1912 where the matter of objects and the elementary vibration are intuitively understood and enabled the work to reflect a total immersion within the world. 'Matter thus resolves itself into numberless vibrations, all linked together in uninterrupted continuity, all bound up with each other, and travelling in every direction like shivers through an immense body' (Bergson 1996: 208).

As the awareness of the immateriality of matter is extended through our conscious understanding, the world becomes deterritorialized and we become molecularized: 'a molecular population, a people of oscillators as so many forces of interaction' (Deleuze and Guattari 1987: 345). The construction of a molecularized society of interactions shifts the boundary of what we see as the autonomy of life.

> This narrativity – which takes place within what I will call the 'scene of disintegration' deterritorializes the components of the body and simultaneously destines the molecular machines of the living cell towards a future where 'life itself' has been 'reshaped.'
>
> (Milburn 2005: 2)

In Will McCarthy's 'Bloom' the molecular society is constructed from the deterritorialized humanity on earth. Creating a swarm intelligence, McCarthy's bloom suggests that life is inherent within the molecule and exists below the cellular level. Jesper Hoffmeyer makes the point that 'the swarm in which intelligence manifests itself is exactly that entity we call the body' (Hoffmeyer 1994).

What Hoffmeyer points out in his writings on swarm intelligence is that

> Biologically speaking, the body can be understood as a swarm of cells and tissues which, unlike the swarms of bees or ants, stick relatively firmly together. However, the swarm of cells constituting a human body is a very different kind of swarm from that of the social insects. The body swarm is not built on ten thousand nearly identical units such as a bee society. Rather it should be seen as a swarm of swarms, i.e., a huge swarm of more or less overlapping swarms of very different kinds. And the minor swarms again are swarm-entities, so that we get a hierarchy of swarms. At all levels these swarms are engaged in distributed problem solving based on an infinitely complicated web of semetic interaction patterns which in the end can only be explained through reference to the actual history of the body system, evolution.
>
> (Hoffmeyer 1994)

In this reference the distributed nature of consciousness via the swarm suggests that inherent in the collective particles are forms of life. The simple collection of cells belies what happens below a cellular level, where cells

themselves are swarms of atoms. What happens when atoms are confronted with the sense and absence of life?

Roy Ascott states that

> While molecular robotics, positional assembly, and self replication suggest exciting possibilities for moving atoms around, building new materials, manufacturing nano machines, and generally building the fundamental blocks of nature into any configuration we desire, there is a danger that the outcomes, even when beneficial in engineering, medical and social terms, could be spiritually hollow, and as such would exacerbate rather than relieve the excessive materialism of our time.
>
> (Ascott 2004)

At a time when advances in nanotechnology are evolving rapidly the fundamental changes that are taking place is via a shift in a subconscious comprehension of the material world. The power to reflect, deduce and develop a critical stance towards a nanotechnological future is fading fast as we become a reflection of its fiction. The final frontier suggested as being nano is obviously not the ultimate boundary but a reflection of scale and investment. However, for now we are having our material world confronted by a nanotechnological science fiction that is becoming factual, believing its own rhetoric. Ascott points out the problem are not the theoretical benefits to mankind but whether this step takes us closer to being 'spiritually hollow'. In a 2002 report to the United States government, nanotechnology is referred to by Richard Smalley as being 'the builder's final frontier', and Horst Stormer who states that nanotechnology has given us 'the ultimate toy box of nature – atoms and molecules. Everything is made from it … The possibilities to create new things appear limitless' (Amato 2000). 'We're using inspiration from life to create new forms of matter,' said Chad Mirkin, director of Northwestern University's International Institute for Nanotechnology in Evanston, Illinois. 'It's a real example of man over nature' (Steenhuysen 2008).

These quotes for the US government report demonstrate a quantitative materialistic and non-sensorial reconfiguration of our position in the world. What is expressed here is a perspectival imposition in seeing the world. The human being has the ownership of all matter and therefore the rights to play in the reconstruction of nature. In these quotes definition of what nature is can become confused and therefore consuming a definition of life.

The developmental process of life has now moved into a posthuman discourse of human and machine and the evolution of 'molecule to sign' (Hoffmeyer 1994). We are confronted with another transformation where the 'moist media' is reinvested with the molecular digital sign existing at a nano level.

The analogically coded sign of the cell and the digital code of the DNA are the main distinction being defined through the language of nanotechnology.

> At the nano-scale, where objects are measured in billionths of meters, the distinction between living and non-living blurs … [H]uman-made nanomachines that are powered by materials taken from living cells are a reality today. It

> won't be long before more and more of the cells' working parts are drafted into the service of human-made nanomachines. As the merging of living-nano and non-living nano becomes more common, the idea of *self-replicating* nanomachines seems less and less like a 'futurist's daydream.'
>
> (ETC Group 2003: 2–5)

The Nanoessence project attempts to place the viewer at a critical point in the discernment of a humanist comprehension of matter and life allowing for the viewer's transmission of their own breath to stimulate and transform via algorithmically generated cellular automaton, artificial life forces. The cellular automatons are originally formed from the difference in data recorded by the AFM of life and death. The questions of life existing as language, through code imply that inherently the object of life is also held within that code. That code can then be distributed and reengineered to create the same object. To associate code with the thought is to suggest that the thought of life inherently holds the material construction of life. To have the idea of life that comes from life must inherently have life in that code. Code is therefore analogous to swarms of atoms creating meanings from a machinic process of pattern recognition.

The material world that is constructed from the swarm of atoms that exist to form a cell or an organ are all 'born out of chaos' (Deleuze and Guattari 1987: 314). This chaos is primordial; it is pattern, vibration and rhythm that construct the boundaries of matter and meaning.

> If pattern is the realization of a certain set of possibilities, randomness is the much, much larger set of everything else, from phenomena that cannot be rendered coherent by a given system's organization to those it cannot perceive at all.
>
> (Hayles 1999)

Hayles' posthuman subject is a construct that is born out of chaos, it is only a pattern within the information feedback loop. The posthuman feedback loop is based on a relationship with technology. Hayles uses the example of the blind man's cane to illustrate the feedback loop, suggesting that in a cybernetic relationship the cane is part of the human. Therefore the realization of pattern creates a set of possibilities for the human to be part machine. This argument garners further support from the recognition of the symbiotic relationship by the seer, it is a perception of technology that is a reflection of the seer. Merleau-Ponty stated that 'since the seer is caught up in what he sees, it is still himself he sees:' the object is the mirror in 'that the seer and the visible reciprocate one another and we no longer know which sees and which is seen' (Merleau-Ponty 1968: 139). Here the human and machine become one as the seer and seen coalesce the processes into a symbiosis.

Eugene Thacker states that a swarm may

> exhibit a discernible global pattern, but this does not mean that a swarm prioritizes the group over the individual. Because of this, a swarm does not exist at a local or global level, but at a third level, where multiplicity and relation intersect.
>
> (Thacker 2004)

The swarm of atoms then is to be constructed in many different configurations based on the individual's ability to define patterns whilst being an example of a recognized pattern. The formation of a recognizable pattern that is durable and consistent allows at that point for the pattern to be determined, understood and communicated. The feedback loop is not just with the blind man's cane but the story of the totality of patterns sensed and realized at a nano level through the touch of the AFM's cantilever.

Nanotechnology allows for the Nanoessence installation to happen at the level of the construction and transmission of life's patterns, meanings and rhythms, not in the material sense of reshaping nature atom by atom but in the complex understanding of the atom's role in the construction of a feedback loop with the seer.

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Contributor details

Dr Paul Thomas is the coordinator of the Master of Electronic Art and the Studio Electronic Arts (SEA) at Curtin University of Technology. In 2000 Paul instigated and was the founding Director of the Biennale of Electronic Arts Perth 2002, 2004. Paul has been working in the area of electronic arts since 1981 when he co-founded the group Media-Space, which was part of the first global link up with artists connected to ARTEX. Paul's own recent practice led research the Midas project exhibited at Enter3 in Prague 2007 was in collaboration with the Nano Research Institute, Curtin University of Technology and SymbioticA at the University of Western Australia, where he is researching the transition phase between skin and gold. Paul is currently working on a commissioned intelligent architecture public art work for the Curtin Mineral and Chemistry Research Precinct in collaboration with Chris Malcolm (John Curtin Gallery) and Mike Phillips (Director of IDat). Paul was on the Media Art Histories program committee for the re:place conference in Berlin 2007 and is now the co-chair for the next conference, re:live in Melbourne 2009. Paul completed a Ph.D. researching a reconfiguration of spatial attitudes, and is a practicing electronic artist whose research can be seen on his website visiblespace.com.

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