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Steep (I): a digital poetry of gold nanoparticles

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Abstract

Gold exists simultaneously as reality and myth in a kind of superposition (a term from quantum mechanics referring to the ability to simultaneously occupy two positions such as yes/no or one/zero). In ancient times, Kings Croesus and Midas were real life, historical figures that exist in contemporary life primarily as myths/metaphors referencing gold. More recent stories such as those of the Klondike and other gold rushes reinforce gold's position in the imagination as an object of desire promising untold wealth and/or misery.

There is another level where gold exists: as a material at the nanoscale, a nanoparticle. At this level, gold inhabits another superposition of sorts where it is inference (we can't see at the nanoscale) but equipment which can sense nanoparticles renders the information visually to us as an object.

Steep, a gold nanoparticle collaboration between Raewyn Turner, Brian Harris, Mark Wiesner, and Maryse de la Giroday along with a rotating list of collaborators is a multi-year, multi-disciplinary, and multi-installation project exploring the superposition (mythic and real) posed by gold nanoparticles. *Steep (I): digital poetry of gold nanoparticles*, the subject of this proposal and the first of the collaborations, is an artistic/poetic exploration of how these mythic/real particles may be affecting, changing, and disrupting the understandings we have of ourselves and our environments.

Keywords

nanotechnology, gold, nanoparticles, myth, metaphor, nanoscale, macroscale, environment, art/science, poetry

Introduction

There are many, many types of nanoparticles including gold, silver, aluminum, carbon, plastic, silicon, copper, and more. They are not new; we have been producing, inadvertently, various nanoparticles for millennia. Examples of 'ancient' nanoparticle-enhanced materials include the Lycurgus Cup (gold and silver nanoparticles, 4th century CE, Late Roman), the red colouring in medieval stained glass windows (gold nanoparticles), and Damascus steel blades (carbon nanotubes found in the blades which were produced until 1700 when production ceased). [1]

More recently (in the last 20 – 25 years) we have begun to manufacture all manner of nanoparticles, including gold nanoparticles, purposefully. The belief is that nanotechnology along with a set of associated emerging technologies such as robotics, synthetic biology, and artificial intelligence will have an impact equal to or even more disruptive than the Industrial Revolution's effects on agriculture, transportation, medicine, the arts, work, and all manner of existence.

Addressing some of the changes, issues, and ideas arising from nanotechnology and an associated set of emerging technologies is a grand task and *Steep (I): a digital poetry of gold nanoparticles* is, proportionately speaking, the equivalent of offering a single nanoparticle's worth (one billionth of a metre) as party to the endeavour.

Golden histories

Gold, despite modern challenges from platinum and palladium, has been and remains the most prized metal across cultures and throughout history.

King Croesus's name has been a synonym for wealth for centuries,

"… [John Gower] in Confessio amantis (1390):

> That if the tresor of Cresus
>
> And al the gold Octovien,
> Forth with the richesse Yndien
> Of Perles and of riche stones,
> Were al togedre myn at ones…"

Croesus was King of Lydia (560 -547 BCE) and is credited as being the first to produce and use gold coins as a means of exchange. [2] As for the other 'King' myth, there were at least three individuals named King Midas but the one who survives best is the mythological entity turning everything his hand touched to gold. [3]

In real life, the Lycurgus Cup (4th century CE Rome) is an outstanding example of how gold can play multiple roles. It is a cage cup made of gold extracted from the earth and beaten and heated for shaping. This cage holds a second cup, one made of glass and fashioned with gold and silver nanoparticles which endow it with extraordinary optical effects. It glows red (Figure 1) or green (Figure 2) depending on how the light shines on it. [4]

The 'Cup' is an iconic nanotechnology image gracing the cover of the British Society's 2004 report "Nanoscience and nanotechnologies: opportunities and

uncertainties," which was written in response to concerns from Prince Charles about nanotechnology and a 'goo' scenario (the possibility that nanoscale devices, self-assemblers, would begin to self-assemble uncontrollably and ceaselessly snatching atoms from everything they came in contact with resulting in a denuded world of 'goo'). [5, 6] Feelings have calmed since that time, possibly due to the Lycurgus Cup itself, which demonstrates a benign and beautiful use of nanotechnology.

Figure 1. Lycurgus Cup (owned by the British Museum) glows red when backlit. Credit: Johnbod, 2010, no flash. Image is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. Downloaded from http://commons.wikimedia.org/wiki/File:Brit_Mus_13sept10_brooches_etc_046.jpg

Medieval glass windows in European churches with ruby red panes coloured by gold nanoparticles are thought to do more than look beautiful,

> "Professor Zhu said numerous church windows across Europe were decorated with glass coloured in gold nanoparticles.
>
> "For centuries people appreciated only the beautiful works of art, and long life of the colours, but little did they realise that these works of art are also, in modern language, photocatalytic air purifier with nanostructured gold catalyst," Professor Zhu said. [7]

Zhu Huai Yong is a professor at Queensland University of Technology in Australia whose expertise includes the direct photocatalysis of metal nanoparticles.

Moving beyond Europe, researchers found layers of gold foil beaten to a thickness of 100 nanometres when examining Namban screens from Japan's Edo period (1603 – 1868) which they reported in a 2014 paper. [8]

Gold at the nanoscale has been part of our existence since before we had a means of describing it.

Figure 2. Lycurgus Cup (owned by the British Museum) appears green when frontlit. Credit: Johnbod, 2010, with flash. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. Downloaded from http://commons.wikimedia.org/wiki/File:Green_Lycurgus_Cup.jpg

Engineered nanoparticles, gold and otherwise

More recently, we have been exploring the use of materials measured at the nanoscale with a view to exploiting the properties associated with quantum mechanics. The US National Nanotechnology Initiative (NNI) has invested over $21B since the program's inception in 2001. [9] The European Union, the UK, China, Japan, Canada, and Iran are only a few of the other jurisdictions which have invested untold amounts into exploring the quantum properties of nanoscale materials such as gold nanoparticles, carbon nanotubes, etc., with a view to enjoying economic glory as a direct consequence. Businesses too such as IBM, HP

Labs, Intel, L'Oréal, and more have invested extensively in nanotechnology.

Mark Wiesner (Professor of Civil and Environmental Engineering and Director, Center for the Environmental Implications of NanoTechnology [CEINT] at Duke University, North Carolina, US), notes informally there is more than one process for producing/manufacturing gold nanoparticles but this one is in common use today,

> "Gold nanoparticles are made about the same way as silver- you start with a solution of the metal salt and add a reducing agent. You might also include some organic compounds that give the resulting particles a charge that prevents it from forming clusters with other particles. Maybe the most common method is to start with a solution of gold salt like HAuCl4 [aka, Gold Chloride, Hydrogen Tetrachloro Aurate (III), Chloroauric Acid, or Gold Acid Chloride] and use citrate both as the reducing agent and to create negatively charged functional groups on the surface that stabilize the particle against cluster formation." [10]

Irrespective of production techniques, gold nanoparticles have proven to be of tremendous interest in health and medical applications, and in electronics, sensors, etc., and, to a lesser extent, in its use as a catalyst. [11, 12]

While gold nanoparticle-enabled applications are currently coming to market with more being developed every day, there are studies into the risks associated with these materials. The nanoparticles, themselves, have not occasioned the levels of concern aroused by silver nanoparticles and long carbon nanotubes but there are issues. A research team at Stony Brook University (New York state) published a 2013 paper detailing a study which suggested gold nanoparticles could cause cellular toxicity, specifically in certain types of adult stem cells. [13, 14]

Steep collaborative project

Figure 3. Raewyn Turner's hand covered in gold. ©Raewyn Turner, 2014.

As more gold nanoparticles are manufactured and 'pumped' into our air, our water, and our soil, we are becoming 'steeped' in gold as Figure 3 fancifully demonstrates.

This art/science project, initially conceived as a single cross-disciplinary art project invoking the notion of being steeped in something invisible which is both new (nanoscale) and familiar to us over thousands of years (macroscale), was developed by Raewyn Turner (artist) and Brian Harris (electronics designer for film and video). The project was expanded to include Mark Wiesner (previously mentioned Professor at Duke University, North Carolina, US), as a science consultant/collaborator and Maryse de la Giroday (writer) and has been reconceived as a series of virtual and/or physical installations with a rotating cast of collaborators.

One of the challenges of a cross-disciplinary project, including this specific poetry video/animation installation, is integrating the principals' (Maryse de la Giroday and Raewyn Turner) differing and, at times, opposing perspectives on representing gold nanoparticles in digital poetry form. Issues over language be it written, verbal, or visual and attempts to avoid dichotomies, for example, words vs. pictures, have required significant investments of time and effort to reframe the discussion and the approach to creating an installation which represents an emerging science (nanotechnology) and its uncertainties.

Steep (I): a digital poetry of gold nanoparticles

The first installation in the reconceived *Steep* series is *Steep (I): a digital poetry of gold nanoparticles*, and is designed as a poetic trilogy realized through onscreen animation and, in future, as a real life video installation. This trilogy, an onscreen piece, is a 'research work in progress' as poem, as animation, and as science communication. The visuals and language are metaphoric as informed by the science.

Yearning, the first part of the trilogy, focuses on gold and its role as a metal of desire. It takes inspiration from terms such as golden opportunity, golden rule, golden ratio, and others. References to its pursuit (inspired by Shakespeare's, "such stuff as dreams are made on") during the Klondike gold rush (taking place in the Yukon, a Canadian territory lying north of British Columbia and adjacent to the US state of Alaska) will act as metaphor for all the gold rushes. [15] *Yearning*, intended to convey how thoroughly gold permeates our culture and history, will also touch on the process of extracting gold from the earth.

Light/Shadow, the middle part of the trilogy, reviews our current understanding of the metal in its particle form. In effect, making the invisible, visible by proxy emulating how scientists view nanoparticles. (The process most commonly requires a scanning probe microscope of some kind where the probe's tip has been dragged across a substrate, sensing the particles by touch, recording the information as data, and sending the data to a software program, which then represents the data visually.)

More specifically *Light/Shadow*, will reference the optical effects made possible by the particles and seen, for example, in the Lycurgus Cup (previously mentioned) and in a 'golden fleece' developed in New Zealand.

> A gold nanoparticle infused yarn developed by Kiwi scientists is expected to be sold to wealthy buyers of luxury carpets, rugs and furnishings. Unlike the 'golden fleece' of Greek mythology the yarn and completed woollen products will not have a golden colour at this stage.
>
> The Aulana-branded wool has been developed by Professor Jim Johnston and Dr Kerstin Lucas of Victoria University after $3 million of research and development.
>
> A tiny amount of pure gold is combined with wool and the chemistry between the two causes it to bond and produce the colours of purple, grey and blue. [16]

Gold's new found role as a catalyst for chemical reactions, and its more common uses in medical applications are more examples of 'light' while the possibilities of toxicity, 'shadow', will also be represented in word and form. [17, 18, 19, 20, 21, 22, 23]

Finally, *Discovery*, the last part of the trilogy, is a meditation on the worlds represented by the atoms present in gold nanoparticles. Drawing on the notion of Erwin Schrödinger's cloud model of atoms rather than the more commonly taught planetary model (the Bohr Model named after Danish physicist Niels Bohr) and referencing William Wordsworth's 'I Wandered Lonely as a Cloud', also known as, 'Daffodils', *Discovery* hints at how little we know and the volatile state of the research and the knowledge. [24, 25, 26] For example, researchers in Finland published papers in July 2014 and in February 2015 where they noted that gold nanoparticles of 144 atoms behave like gold metal at the macroscale while gold nanoparticles of 102 atoms behave like a giant molecule. Meanwhile, researchers Carnegie Mellon University (in the US) noted in a March 2015 paper that gold nanoparticles of 133 atoms were not yet metallic. [27]

Animating Steep (I)

Yearning's opening visual sequence starts with a distant shot of the planet earth and a descent, drawing closer to show the tops of houses (which resemble nanorods from a certain distance). This sequence and subsequent visual imaging convey the 'yearning' for beauty, riches, and spirit. The visual style changes from one part of the trilogy to the next signifying the shifts in theme while retaining overall cohesiveness. *Light/Shadow's* visual design emphasizes the interplay between light and shadow, with work seen in shadow and gradually revealed. It parallels how bits of scientific information are acquired. Specifically, we are slowly learning about gold nanoparticles, for example, there was the realization that the Lycurgus Cup's optical properties are due to gold and silver nanoparticles. *Discovery* is the most conceptual section using images of gold nanoparticles taken with a specialized microscope to convey the ideas and science underlying the poetry and the notion of being 'steeped in gold'.

The serendipitously named 'particle system technique' produces an effect where visuals dissolve into particles. In this case, the plan is to use the effect so we can represent gold nanoparticles which then reconstitute themselves as new words and/or images. This proposed 'cloud' of gold nanoparticles and text is intended to signify Schrödinger's atomic model and Wordsworth's 'cloud' blending science and poetry with attention being paid to not being overly literal. Animation tools under consideration include After Effects, Maya, Vectorian Giotto, and/or Blender.

A current sample animation (working title: animated words video), included with this submission, features a high resolution aerial photograph of the hills of Hawkes Bay, New Zealand and 'words' (symbols used as placeholders for words) accompanied by music, a Jesse Cooper remix (Ben Sage). Final Cut Pro was used to create the work in progress.

Conclusion

Steep is an international art/science research project examining the impact gold and gold nanoparticles have had in the past and could have in the future. Designed as a multi-year, multidisciplinary project with a rotating cast of collaborators, *Steep* is based on the current state of scientific research and its flexibility as a project reflects the uncertain and disruptive state of nanoscience and nanotechnology (as they are sometimes referred to).

Steep (I) a digital poetry of gold nanoparticles, our first piece, is largely concerned with the elements of air, water, and earth or, more fancifully, gold in all its forms: myth, metaphor, and reality as it transitions visibly and invisibly throughout our environment.

The co-leads (Maryse de la Giroday and Raewyn Turner) for Steep (1) have artistic practices that while grounded in various disciplines exploit the state of 'not knowing'. This requires spontaneity and openness to a state of uncertainty. The following trilogy and video sample accompanying this submission are works in progress and are emblematic not only of the co-leads' artistic practices but of the uncertainties associated with nanotechnology and its disruptive impact (for good and/or ill) socially and environmentally.

a digital poetry of gold nanoparticles

Yearning

shards of sun
hidden in the river's silted bed
buried beneath the earth's skin

a beautiful killing
in the cold, cold river
in the darkness underground

opportunities made of gold
wealth beyond Croesus' and Midas' imaginings
shining brightest

Klondike calls
El Dorado beckons
siren songs of:

safe passage through this vale of tears
alchemical transformation from fear to joy
power over life and death
pleasure unending and unimaginable

kings and paupers answer
build empires
strive for godhood

Buddha, Jesus, Ganesha
and the others
sitting golden in their temples waiting tribute

flesh and spirit
striving towards
a beautiful eternity

Light/Shadow

golden cage
holding
the Romans' particulate offering
two-colour glass rainbow glowing red/green

wounded cerebrum
made whole
nanoporous gold-plated electrodes
electrifying neurons

New Zealand's woolen fleece
economy wrapped in gold
gleaming lavender

stromal cells
collecting
gold ceaselessly
until
a failure
to regenerate

European cathedrals paned in
photocatalytic purifiers made of gold particles
blazing red

mining nanogold in
sewers
deposits richer than the earth

harvesting the sun
with a fishnet made of gold
Au 144

poisonous nonpoison circulating
the air
the earth
the sea

Discovery

wandering lonely as cloud
a host of golden nanoparticles
rains down on earth

superpositioned quantum world
dead/alive
metal/molecule

classical physics
dead or alive
metal or molecule

simultaneous and incompatible truths
for now

metal particles—144 atoms of gold—Au_{144}
molecular particles —133 atoms of gold—Au_{133}
transmutation of Au particles from metal to molecule and back

Nature's alchemy
breathing them
eating them
drinking them
we become gold
discovering what we are

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Author Biographies

Maryse de la Giroday, independent scholar, writer, and science blogger received her BA in communication from Simon Fraser University (Burnaby, British Columbia, Canada) and was awarded an MA in creative writing and new media from De Montfort University (Leicester, UK). Her BA honours project resulted in a video, "Bridging the Cultural Gap" on intercultural communication used as a teaching tool in Canada and the U.S. Her MA pro-

ject, “The Nanotech Mysteries: An Initiation into the Science and the Technology wiki” is mentioned in the 3rd edition (May 2014), “Digital Storytelling: A creator's guide to interactive entertainment” by Carolyn Handler Miller. Since 2008, she has written extensively about nanotechnology on her *FrogHeart* blog and has presented on the topic at regional, national and international conferences. During the 2014 autumn semester, she taught two courses, “Bioelectronics, Medical Imaging and Our Bodies” and “Nanotechnology: The Next Big Idea,” at SFU in the Continuing Studies program.

Raewyn Turner’s work is concerned with cross-sensory perception and the uncharted territories of the senses. She works with video, interactive installations and performances, painting and sculpture, working solo and in collaboration with artists, musicians, architects, dancers, performers and academics on installations, theatre performances, exhibitions and screenings. She is also a concept and design theatre artist and lighting designer and operator in large scale international performance in stadiums and theatres, for contemporary music and dance. She has worked in collaboration with Dr Richard Newcomb, molecular biologist, NZ. In 2011 she was recipient of a Fulbright Travel Grant for an artist’s residency at Monell Chemical Senses Center, Philadelphia. Her works have been shown in numerous national and international exhibitions and performances, including ISEA2013, Museum of Contemporary Art, LA, Parque de las Ciencias, Granada, Spain, 11th Prague Quadrennial of Scenography and Theatre Architecture 2007, Prumyslovy Palace, Prague, Argentina, Georges Pompidou Center, and elsewhere.