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PTC 603 Cultural and Technological Change

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The Convergence of Art and Science in History and Contemporary Digital Technology

"What is true? What is beautiful?" asks Edward Teller (1908-2003), the Hungarian physicist, who advised my father's uncle, Admiral Lewis Strauss (1896-1974), to pursue development of the hydrogen bomb. (Strauss relayed his recommendation to former President Truman who decided to proceed.) Teller explains that science and art are and should remain separate:

> Science considers what is true, starting out with almost unimaginable ideas. The job is to understand these ideas and fit them into a broad and logical picture of the universe…Art is the development of what is beautiful...
>
> *Truth, morality, beauty*. It has been humanity's persistent hope that these three ideals should be consistent with each other. Yet successful activities in science, politics, and art diverge greatly, and I believe the three activities can be pursued initially without regard to each other, or without reconciling the possible conflicts that may arise…contradiction and uncertainty should be embraced.
>
> *Contradiction and uncertainty*. Niels Bohr loved contradictions. He would not tolerate the idea that quantum mechanics might some day [sic] supersede classical

> physics. For Bohr, classical physics had to remain in permanent contradiction to quantum mechanics… In the same way, the impacts of science, politics, and art must remain independent. We must learn to live with contradictions, because they lead to deeper and more effective understanding. The same applies to uncertainty (Teller 1200-1201).

Charles Percy Snow (1905-1980), an English physicist and novelist set out to show that the gulf between science and the arts is a threat to the survival of western civilization in his 1959 lecture and subsequent book (age_of_the_sage.org). He wrote:

> There have been plenty of days when I have spent the working hours with scientists and then gone off at night with some literary colleagues…[and] through moving regularly from one to the other and back again … I got occupied with the problem …I christened to myself as the 'two cultures'. For constantly I felt I was moving among two groups…who had almost ceased to communicate at all, [whose] intellectual, moral and psychological climate had so little in common… (Snow 2).

> …I believe the intellectual life of the whole of western society is increasingly being split into two polar groups… (Snow 3).

> Literary intellectuals at one pole – at the other scientists... Between the two a gulf of mutual incomprehension … (Snow 2-4).

He points out that education, or the lack thereof is the culprit – scientists know little of the literary and the literary know little of the scientific.

Of the scientists…

> [W]e came across several who had read everything that literary people talk about. But that's very rare. Most of the rest, when one tried to probe for what books they had read, would modestly confess, 'Well, I've *tried* a bit of Dickens', rather as though Dickens were an extraordinarily esoteric, tangled and dubiously rewarding writer… (Snow 12).

And of the literary…

> I have been present at gatherings of people who …are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked… how many of them could describe the Second Law of Thermodynamics. The response was cold... Yet I was asking something which is about the scientific equivalent of: *Have you read a work of Shakespeare's?* (age_of_the_sage)

The Artist and the Scientist

The artist is concerned with external reality, and the inner realm of emotions, myths, dreams, and the spirit (Shlain 22); the "in here" space of imagination or "subjective" reality (Shlain 29). While the scientist is a seeker of knowledge based upon objectivity, method, and reliability where reality is ‘out there;’ “material explanations for observable phenomena are always sufficient and metaphysical explanations are never needed” (Bernard 10).

“Artists as well as scientists work with abstract symbols, representations for various realities…the intellectual bridge of abstraction and aesthetic consideration is fundamental to both groups” (Sorensen). And, although art and science each have their own lexicon used in distinctive syntax, the concepts – “volume,” “space,” “light,” “color,” and “tension” – of one can be applied to the other (Shlain 19-20).

Many artists and scientists think visually. Artists work with drawings and create spatial models in their minds; and, scientists frequently work from “visual geometric models in their minds” from which they identify research problems and pre-visualize potential solutions. As well, both artists and scientists think creatively – building upon stored knowledge they work with their imaginations and intuition (Sorensen).

Shlain compares art and science (in terms of physics) to a wave and a particle; they are an integrated duality. As such, “they are simply two different but complementary facets of a single description of the world” (24).

The History of Art and Science

Prehistoric paintings found in caves such as Lascaux in southern France are the first evidence of art, but it’s impossible to know the status of the artist (Strosberg 26).

The roots of modern science began with the ancient Greeks who developed the alphabet with vowels, civilization's first abstract art form. Before the Greeks, every belief system worldwide mixed the inner space of the dream, trance, and myth with the events of everyday existence (Shlain 28). The Greeks introduced rational thought, and investigated the nature of reality with their newly refined tool called "reason," sweeping away all mystical and magical explanations and replacing them with logic. (Shlain 29). Also, the mathematician Euclid codified the field of geometry, and Aristotle, by transforming the three Fates into Past, Present, and Future, created linear time and formulated the rules of logic (Shlain 30-2). But, the Greeks found arts and crafts to be synonymous; those who did such work were low artisans.

The conquering Romans embraced the Greek worldview and modeled their culture after it (Shlain 36). After the fall of Rome in the fifth century both art and science faded into the background until the Middle Ages when knowledge re-emerged slowly.

Modern science was born (Shlain 56) in the Renaissance as scientists began to compare ancient Greek philosophical speculations with actual observations from nature; their logical explanations for the world as opposed to spiritual ones slowly eroded religious dogma (Strosberg 28). Galileo (1564), considered the founder of modern science, originated the idea of observation, experimentation, and measurement, each central to the scientific method. Francis Bacon (1561-1626), an empiricist, emphasized induction, "the use of direct observation to confirm ideas and the linking together of observed facts to form theories …of how natural phenomena work" (Bernard 12). Newton (1643-1727) went a step further combining induction with deduction (reason). As well, many of the world's greatest artists including Leonardo, Michelangelo, Raphael and Titian, came into their own during the Renaissance; they built upon the techniques of the ancient Greeks and strove to surpass them. (Howells 54). Leonardo da Vinci, wrote, “Art truly is a science” (Strasberg 148); in essence, “[u]sing both brush and pen, Leonardo changed the way we *see* the world and this subtle shift in mind-set prepared people to be receptive when Newton introduced a new way to *think* about the world” (Shlain 83).

Subsequent artists found it difficult to improve upon the Renaissance artists and resorted to “restless and hectic attempts” to surpass them. But Rembrandt stands out as the greatest seventeenth century painter. Increasingly, in the eighteenth century, artists like William Blake broke with tradition and produced more personal art. The industrial age in the nineteenth century undermined the foundations of art (Howells 54-6). With the invention of photography, it was perceived that artists were no longer needed to paint reality. In response, many artists turned to interpreting reality (Strosberg 29). Howells quotes Gombrich, “For the first time, perhaps, it became true that art was a perfect means of expressing individuality,” (Howells 56). In the meantime, scientists increasingly explained the world in objective, empirical terms, leaving the subjective, emotional concerns to the artist (Strosberg 29).

Art and science continued on parallel paths into the twentieth century. Although unbeknownst to each other, Picasso’s Cubism and Einstein’s theory of relativity share conceptual relationships; that is, the “profound distortions of everyday time and space” (Shlain 224). For the first time, emerging theories of quantum mechanics and Einstein’s theories produced a climate whereby no one except the discoverer and a “select number of cognoscenti” were able to understand contemporary scientific discoveries. About the same time too, dissatisfaction grew among artists characterized by Cezanne's indifference to 'correct drawing.' Resultant new movements in art – Fauvism, Cubism, Dadaism, and surrealism – confused the public; to them, art had become incomprehensible. (Shlain 222). The ideas of interaction, concept rather than object, and 'virtuality' in Dada (1916-early1920s), Fluxus and conceptual art movements (1960s) influenced digital art (Paul 11-5).

The use of digital technology was dominated primarily by the scientist during the early years of digital computing in the 1940s and 1950s. But since the 1960s, advances in digital technology, along with its democratization, particularly since the 1980s and 90s, have allowed for the proliferation of computers across society. Today digital art spans the disciplines of art, science, technology, and design. (Paul 22)

Visual Instrumentation in Science and Art

Perspective

According to Howells, "the problem of perspective was one of the most challenging of the history of art…[and] the solution was, as is often the case in science" (Howells 139). The Florentine architect Filippo Brunelleschi (1377-1446) is credited with the invention of linear perspective which gives the illusion that onlookers are viewing a scene through 'a hole in the wall' rather than a flat two dimensional surface creating the dimension of depth (Howells, 54). In linear perspective parallel lines converge at a point on the horizon. As objects recede toward the horizon, they decrease in size proportionally (Strasberg 27, 70).

The first written 'secret' of perspective was Leon Battista Alberti's (1406-1472) *Della Pittura* (On Painting) book in 1435-6 (Howells 139) which made extensive use of Euclidean principles to explain the technique. “By painting a scene from one stationary point of view, an artist could now arrange three axes of the geometry of space in their proper relationship” (Shlain 53).

According to Ihde, Alberti regularly used the camera obscura; and therefore, it played a prominent role in the development of perspective (Ihde 42). In addition, Leonardo da Vinci, wrote about perspective, distinguishing three aspects: as objects recede into space they are proportionally reduced in size, color clarity, and detail (Suh 7, 9).

The knowledge of perspective was confined to Italy until Durer, a northern painter, who studied perspective and the art of illusion in Italy, published two books on the subject in German in 1525 and 1528. As a result, knowledge of perspective was introduced to northern European artists.

Camera Obscura

The camera obscura, an early modern visual technology (Ihde 42), means ‘dark room.’ Howells contends that as early as the tenth century it was known that a darkened room with a small hole opened to daylight would project a color image – upside down – onto the opposing wall, and although dim, and or blurred, could then be manually traced. (Howells 152 Hockney 200). As such, the camera obscura reduces three-dimensional objects to two-dimensional images – an isomorphic “reduction” (Ihde 42).

It is known that northern artists were painting realistically before Durer published his books on perspective. The first evidence Hockney has of artists painting with a camera obscura is in the early 1400s. According to his observations, between 1420 and 1430 in Flanders, there was a sudden “shift towards greater naturalism from the fifteenth century to the nineteenth… that was immediately coherent and complete.” Hockney attributes this sudden change to a technical innovation – a camera obscura with a mirror-lens (Hockney 87) – rather than a new way of looking. Among the evidence to support his view is pointing patterns on folds and shine on armor; abilities the new optical devices allow for but linear perspective does not (Hockney 51). But the concave lenses used at the time yielded an image projection of limited size.

Optics reached Italy in the late 1400s, and by 1500 Leonardo da Vinci was writing his detailed account on the camera obscura. At the end of the sixteenth century, conventional lenses replaced concave lenses with the advantage of a wider field of view (Hockney 103), but they reversed the image. By 1600, there is an “amazing burst of naturalism” in paintings as good-quality flat mirrors that reversed the image back were introduced (Hockney 118). And, by the eighteenth century, with the advancement of lens technology, camera obscuras, fashioned as boxes, could be purchased in shops (Hockney 130).

Telescope/Microscope

Roger Bacon (1214-1294) described lenses, and eyeglasses, the simplest level of optics which merely correct vision. The next level of optics complexity, the telescope which along with the microscope enhances vision through magnification, was not discovered until three hundred years after the first recorded use of eyeglasses (Strasberg 112, Ihde xi, 42).

Hockney contends that Cardinal del Monte, patron of Caravaggio (1571-1610), and advisor to Galileo (1564-1642) who bought antiquities from the scientist Giambattista della Porta knew lenses could make pictures (Hockney 218) and gave those lenses to Caravaggio. Caravaggio's chiaroscuro style (the play of light and shade) spread across Europe amongst artists concurrently with the rapid spread of telescopes. At the time, lenses were ground and polished glass often crafted by scholars such as Spinoza (Hockney 222). The telescope, an invention based on lenses perfected by Dutch opticians, was initially developed for the military (Strasberg 72). Scientific visualization took a major step forward when Galileo perfected the telescope in 1609, and looking to the heavens, made several discoveries, particularly the moons of Jupiter (Levy 167). He recognized that the "new visual phenomena" he was seeing through his telescope was real (Ihde 42). This visual view was multisensory and embodied. As he gazed at the objects in space, they became larger and, at the same time, they became a center of focus close up. This change in distance is a reflexive interaction between object magnified and bodily position in order to compensate for the earth's movement (Ihde 53-9).

With meticulous detail, the Dutchman Antoni van Leeuwenhook (1632-1723) ground his own lenses and mounted them in his own metal shafts. He built hundreds of microscopes. "He made better and better lenses with the fanatical persistence of a lunatic; … he examined everything, the intimate things and the most shocking things" – and was the first to see the microscopic world (Levy 7). He documented every detail of what he saw to a skeptical Royal Society, all except how he made his microscopes. In response, the Royal Society commissioned Robert Hooke to build the best microscope and reproduce Leeuwenhook's findings. "And, on the 15th of November, 1677, Hooke came carrying his microscope to the meeting – agog – for Antony Leeuwenhoek had not lied. Here they were, those enchanted beasts!" (Levy 14)

Looking through a telescope or microscope is solitary activity, and to show others what is seen, it is common to make a drawing. This requires two matrices for subjectivity to be surpassed, the skilled vision through the instrument, and the skilled representation of the object by the hand (Ihde 43).

Photography

Photography was the most rapidly accepted and adapted imaging technology in the history of science (Ihde 42-3) because it, like the camera obscura, reduced the object to an isomorphic image; but in addition, it did so automatically, without subjectivity, and fixed the image onto a photographic plate (Ihde 43).

Photography requires two sciences – physics and chemistry. The physics was worked out first with the camera obscura. But fixing the image had to wait for advances in chemistry – key was the discovery by Johann Heinrich Schulze in 1727 that certain kinds of silver chemicals were photo-sensitive; that is, they turned dark when exposed to light. Subsequently, Wedgwood succeeded in producing primitive negatives, but was not able to fix the image; they continued to darken over time. The Frenchman Joseph Nicephore Niepce is attributed with producing the first real photograph in 1827; he called it a heliograph or 'sun drawing' for it required exposure to sunlight for about eight hours. Daguerre unveiled his process which improved upon Niepce's in 1839. Although Daguerre produced a positive image, only one copy could be made. Nevertheless, the daguerreotype spread as small-town photographers set up shops to take portraits; people who could not afford to commission a painting could now afford a daguerreotype. William Henry Fox Talbot, working concurrently but independently of Daguerre, developed a process using paper which was lighter and less expensive than Daguerre's, and he used a camera. But most importantly, he invented the positive-negative process turning photography into a truly reproducible medium. In effect, from one negative, almost an unlimited number of prints could be produced. In 1888, George Eastman's portable, preloaded Kodak camera brought photography to the general public. Now, anyone, not just the professionals, could take pictures spontaneously. Further developments followed, the 35mm camera by Leica in 1925, color film by Kodak in 1935, the Polaroid camera by Edwin Land in 1947, and the electronic still camera by Sony in 1982 (Howells 152-6).

"With photography, perspective and proportion …were mechanically achievable from the outset" (Howells 168) obliterating the alliance between painting and science that Alberti established in linear perspective. It brought a new way of seeing the world whereby the photograph represented an authenticity between the object photographed and the photograph itself – an authenticity that could not be achieved with the hand. In addition, it allowed for the transformation in time. For example, in1878 Muybridge photographed galloping horses and confirmed that all feet come off the ground together – movements that previously were not perceivable by the human eye (Ihde 43). People began to believe that when they looked at a photograph they were looking at reality itself (Howells 158) – "photographs had become the standard recorders of scientific truth" (Ihde 43).

Although scientists supported photography, most artists avoided it, seeing photography as a threat to their mission to represent the world (Strasberg 200). In response, they looked elsewhere for alternative ways of seeing giving rise to modern art (Hockney 185).

Digital Technology

Beginning at about the same time, the development of computing and media followed parallel courses until they converged recently with digital computers.

Computer graphics began in 1800 with Jacquard's loom; controlled by punched paper cards, it wove intricate figurative images. Babbage, in 1833, inspired by Jacquard's loom, designed the Analytic Engine, a general numerical calculating computer. Although never developed, it foreshadowed the digital computer. (According to an article in the New York Times, researchers in Britain are about to embark on building Babbage's computer (Markoff).) Ada Augusta, the first programmer remarked, "The Analytic Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves" (Manovich 22).

After the development of photography in 1839, many improvements were implemented until the 1890s when the still picture was put into motion laying the foundation for modern cinema. Also, tabulators and calculators became increasingly faster and more common. For the 1890 census, the Census Bureau employed Hollerith's electronic tabulating machines which collected census data on cards. (Manovich).

The work of Marcel Duchamp (1887-1968), a Dadaist artist, represents a shift in art from object to concept. His *Rotary Glass Plates (Precision Optics)*, 1920, is an early example of interactive art. And his readymades, such as *Fountain*, 1917 (Wikipedia), foreshadowed the digital readymades of today – "selection from a menu of choices" (Manovich 126).

In 1936 Turing's "the Universal Turing Machine" read numbers, performed calculations and wrote the results on a continuously moving tape, similar to a film projector. Also that year, Zuse built the first working digital computer using punched tape – discarded 35mm movie film – to control its programs (Manovich 24-5).

Then in the 1940s programmable digital computers like the ENIAC were introduced as calculating engines mainly for military and scientific applications. Since then, each decade has seen a steady progression of digital technology (Paul 9).

In the 1950s, commercial computers were introduced; beginning with the UNIVAC in 1951 (Paul 9). Then in the 1960s, computer-graphics researchers, like Coons and Roberts, developed computer algorithms based upon Alberti's linear perspective (Mitchell 118). New digital image-processing techniques applied to scientific applications were first used by NASA in 1964 on lunar surface images. And, the first digital images by 'artists' like A. Michael Noll at Bell Laboratories appear to be abstract drawings, but were programmed as a mathematical functions (Noll, Paul 29). In the 1960s too, Fluxus artists fused audience participation and event, anticipating interactive, event-based computer art (Paul 13).

The first word processor appeared in the 1970s (Landow 35) followed by the desktop computer in the 1980s. At the same time, artists, using new technology, such as satellites and networks, began experimenting with 'live performances' and networks, anticipating current interactions on the internet (Paul 18).

During the 1990s the identity of the computer changed from simulation of a typewriter, paintbrush or drafting ruler at the beginning of the decade to universal media machine by the end of the decade due to the advent of the Internet (Manovich 69). As such, the computer became “an image capturer, presenter, and manipulator” (Landow 35) where “graphics, animation, video, and audio” were important (Bolter xi) as well as hypertext – encompassing the traditions of cinema, print and HCI (Manovich 70). Also in the mid 1990s, the digital camera became widely available (Howells 152-6).

Current themes in digital art mirror themes in digital computing in general including artificial life and intelligence, mapping and visualization, telerobotics, tactical media, social networks, gaming, mobile media, and virtual worlds as well as biotechnology (Paul 139).

The Merging of Art and Science in Digital Art

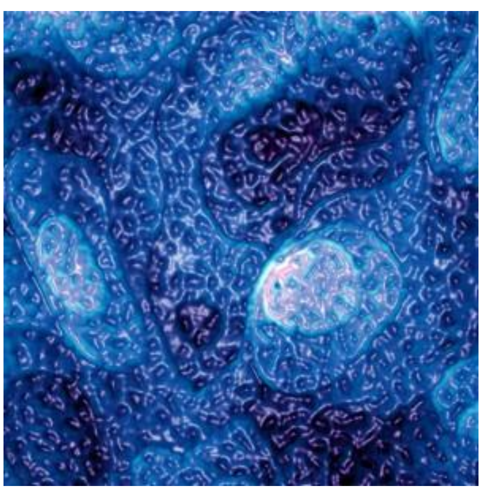
Digital art brings together the disciplines of science and art as well as technology and design. As such, it is the result of engineers and scientists as ‘artists,’ artists using digital technology in ways not intended, and artists, engineers, scientists, and or programmers collaborating to create digital art works. (Paul 16-22).

The Scientist Artists

Scientific Instrumentation - Seth Darling and Steven Sibener

Digital computers which construct a vision – perspective views of objects that are too small to see, too far away, or otherwise not viewable (Mitchell 12) – are the most complex type of scientific instrumentation (Ihde xi). These computer image-processing systems are based on sophisticated mathematical theory of digital image transformation and combination, and employ devices that capture, store, transmit, and display digital images (Mitchell 11-2). Although the resulting images look like photographs, they are non-photographic. They are constructed as digital models based upon observations that are translated into predictions of what *would* be seen under certain viewing conditions (Michell 64). Unlike renderings made by hand, these visualization procedures can be tested and validated thus producing highly credible images (Mitchell 118-9). "The irony of contemporary high-technology instrumentation is [that] scientific instruments can more clearly, more precisely, and more profoundly deliver data/images than in any previous era of human history … There is something of an inverse proportion law at play – the better the data/image, the more constructed it has been" (Ihde 136).

Beginning in the 1970s and 1980s scientists developed powerful scanning probe microscopes to visualize atomic surface variations. These computer image-processing systems (Mitchell 12) generate the image from three dimensional scanner data (Mitchell 118-9).



"Rough Water" by Seth Darling and Steven Sibener

Using an atomic force microscope, a type of scanning probe microscope, scientists Seth Darling and Steven Sibener captured their award-winning image, *Rough Water* which appears to be an ocean, but is in fact a single layer of molecules a mere nanometer deep. The turquoise and indigo colors are artificial, but the "choppy waves" are real. It won first place in Photography at the annual 2010 *Science*/International Science & Engineering Visualization Challenge which aims to promote "cutting-edge efforts to visualize scientific data, principles and ideas" (Nesbit). According to Darling, "… every once in a while when you're looking through a microscope, actually, fairly often, an image immediately strikes you as being beautiful… you look into the microscope, you see something that has beautiful form, beautiful color, or a combination of those two – and there it is, nature is giving you the art all by itself. In my view, there's really two … ways that art and science relate to one another. One way is the features that they share and the other would be more practical ways in which they relate … for example, creativity is central to both, you can't be an effective scientist or an effective artist without a good sense of creativity and patterns and symmetry are something that appear regularly in both of these fields, so I think it is natural that there be interactions between art and science for those reasons" (Darling).

At the University of Chicago's "The Art of Science" program in 2010, scientist Mike Pappa from Argonne noted that art helps scientists move their research to new levels of exploration. He said, "An experiment that simulates the explosion of a star can create more than one billion data points. Artistic representation is a powerful tool that helps scientists make sense of mountains of data and furthers their experiments" (Borzo).

Photography - Ariel Ruiz i Altaba

Basic to digital media is its potential for multiple kinds of manipulation and seamless combination of art forms. A digital image may be part scanned photograph, part computer-synthesized shaded perspective, and part electronic "painting" – all smoothly melded into an apparently coherent whole (Mitchell 7). Such works appear as synthetic realism, appearing both artificial and familiar at the same time (Paul 37).

Ariel Ruiz i Altaba – an artist first, and molecular biologist second – explore the intersection of art and science using an array of both digital and analog photographic technologies (Bly 76). When using digital technologies as a tool, the work may display distinctive characteristics of the digital medium that reflects on its language and aesthetics, or the work may be a subtle blend of technologies that makes it hard to determine whether it has been created by means of digital or analogue processes. A work that appears to have been created through digital manipulation may have been created entirely by means of traditional techniques, while one appearing to be entirely handmade may have undergone digital processing (Paul 27). In the case of Ruiz i Altaba's work, as viewers, we are not quite sure how they were created. "He uses a vast range of cameras, from 35mm and medium format equipment to Polaroids, plastic cameras, and pinhole devices." He said, "I use a variety of methods to develop my pictures – old and new, 19th century, gelatin silver and digital… I develop the negatives and sometimes paint the prints chemically and replace the silver for other metals, or with different paints… (Joshi 145-6).

Ruiz i Altaba continues, "My interest in art began long before I became a scientist. But, as much as I try to keep these two separate, I cannot help but be influenced with what I do and see." Looking through the microscope: "I saw these fantastic images forming before me – valleys and mountains, with different contours, contrasts, shades and moods, depths and colours" (Joshi 145-7). Two series of photographs, *Embryonic Landscapes* and *Minimal Landscapes* of developing non-human embryos (Joshi 147), depicts biological iconography as "landscapes" that skew reality – “[I] try to stay far from what may be perceived as consensus reality… because I’m sort of perverting the ideas of documentation in science” (Bly 78).

“The photographs of *Embryonic Landscapes* (Actar, 2001) show visual abstractions from the embryonic world in black and white…These biomorphic abstractions engage our inquiry through the surprise they generate as we cannot immediately place them in a given context or magnitude. [They] are devoid of referents such as color or scale …[and] question our understanding of nature and of ourselves through their multiple layers of information, from a purely aesthetic to a more conceptual, empirical and scientific content. These images, however, are not documents pretending to reveal scientific realities” (Ruiz i Altaba).

“Embryonic Landscapes” by Ariel Ruiz i Altaba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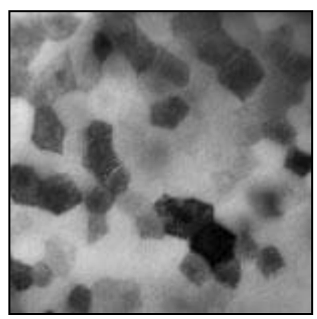
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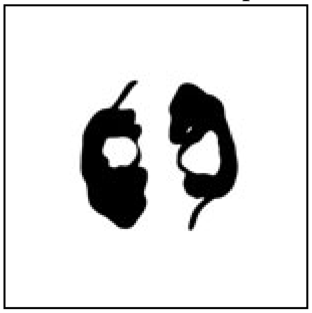
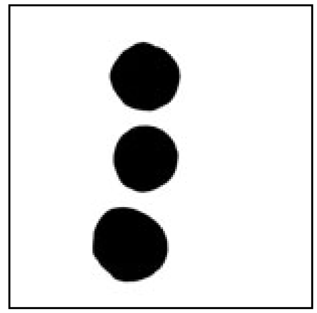
“Minimal Landscapes represents an exploration of form in its essence, devoid of distracting elements. The photographic images show black islands forming archipelagoes of explicit and implicit meanings that become imaginary landscapes in the viewer’s mind” (Ruiz i Altaba).

“Minimal Landscapes”by Ariel Ruiz i Altaba

 *Lonliness in your dreams*  *Traces de llum*

Ruiz i Altaba believes that photographs are not ‘shot’ – they are constructed. “You do not really capture images. You choose the framing, the mood” (Joshi 147). “While framing an image, we make certain key decisions to interpret the reality that we perceive. That, in fact, clearly proves that impossibility to capture or shoot reality” (Joshi 147).

Scientific Software and Unintended Uses - Joan Fontcuberta

Scenary-rendering software which interprets topographical maps such as Digital Elevation Model (DEM) files (produced by the U.S. Geological Survey) to re-create real world landscapes is based on the concept of fractal geometry developed by the mathematician Benoit Mandelbrot who in the late 1970s created the first trial images of fractal mountains. Richard Voss helped Mandelbrot generate the first realistic virtual landscapes in the early 1980s, and by the end of the decade, F. Kenton Musgrave achieved genuinely photorealistic results. Since these programs are designed to interpret *maps* – abstractions of cartographic information – their vocabulary is limited to generate only the forms of valleys, lakes, or clouds.

One such program, Terragen, originally designed for military or scientific use, was employed by the artist Joan Fontcuberta in his *On Orogenesis* project to transform paintings into virtual landscapes, in effect, creating alternate realities. As such, the images (which can be found in his book, *landscapes without memory*) produced from electronic scans of paintings of artists such as Turner, Derain and Cezanne are products of deception. Fontcuberta tricked the computer program into performing transformations not envisaged in its design forcing it to interpret images that are not maps, but instead, other landscapes (Fontcuberta 6, 9).

Fontcuberta took his inspiration from his experience at an artist's residency in the Canadian Rocky Mountains. "The majesty of forests, lakes, glaciers, and mountains, under clean skies with dramatic clouds, induces a special state of mind … both spiritual centeredness and creative inspiration. But, paradoxically, for … me, coming from an urban environment of crowds, noise, and exhaust fumes, all that peace and purity seemed less like a nature reserve than like an artificial set... A nature so perfect could not be true… My firsthand experience of that virgin nature reserve … was confronted with incipient technologies designed to reconstruct it virtually. *Natural* nature was becoming transmuted, symbolically, into *artificial* nature. It was clear that what had once been the most dependable medium for representing nature, photography, was in the process of being supplanted – the so-called Pencil of Nature was now becoming the Pencil of Technology … [whereby] the refinement of these programs threatens the iconic status of the photograph as a literal transcription of reality." For these 'post landscapes' are familiar, but yet garner the illusion that we are present in a place where no human has walked, whose terrains have been formed not by tectonic movements and slow erosion of millions of years, but by a simple process that translates alphanumeric data as mountains, craters, lakes…These are landscapes without memory, without history: nothing has happened in them…

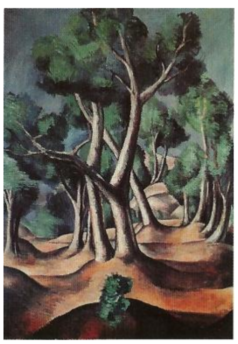
They are mute spaces, mountains with no echoes, lakes without a ripple, silent waterfalls.

(Fontcuberta 4-5, 7, 9).

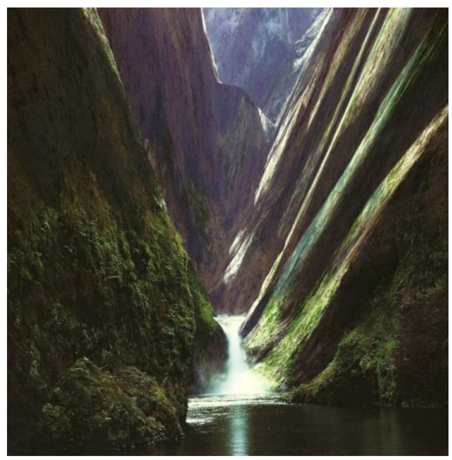
"On Orogenesis" by Joan Fontcuberta

Turner, *The Burning of the Houses of Lords and Commons*

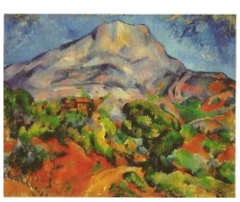
Orogenesis: Turner,2003



Derain, *The Grove*



Orogenesis: Derain, 2004



Cezanne, *Mont Sainte-Victoire*

Orogeneisis: Cezanne, 2003

In one of his essays on the sublime, Jean-François Lyotard conjures “the possibility that photography has rendered the profession of painting ‘impossible,’ meaning …that ‘painting’s impossibility arises from the industrial and postindustrial – technoscientific – world’s greater need for photography than painting.’ Photography now faces that same impossibility, having been definitively superceded in its informational capacities by the computer and its omnivorous, algorithmic notations.” Fontcuberta has produced “an ‘experience of the impossible,’ sublimely banal landscapes that have never been and never will be” (Fontcuberta 13).

Collaborations: Scientists, Artists, Programmers

Artificial Life

According to George Dyson, the first person to create Artificial Life digitally was Nils Aall Barricelli in the 1950s. Dyson recently found the punchcards containing Barricelli’s “creatures” (Dyson). Since then many researchers have attempted to create Artificial Life. Christophe Adami, in his TED talk, explains that Artificial Life began with computer viruses that researchers wrote, but although they behaved in a similar manner to real viruses, they could not be considered life because they did not evolve on their own. Steen Rasmussen, a scientist at the Scientific Institute, attempted to create Artificial Life by packaging the viruses so they could evolve on their own, but instead they destroyed each other (Adami).

Tierra

Thomas A. Ray, an ecologist, realizing how to fix Rasmussen’s problem, created his *Tierra* software program (Wilson 352). He introduced *Tierra* at the Fourth Conference on Artificial Life in 1994 and suggested it be released on the Internet so that it could “breed” diverse species on computers all over the world – this way, diversity could be extended for silicon-based life-forms (Hayley 223-4). Ray described his approach to *Tierra* as:

> Life on Earth is the product of evolution by natural selection operating in the medium of carbon chemistry. However, in theory, the process of evolution is neither limited to occurring on the Earth, nor in carbon chemistry. Just as it may occur on other planets, it may also operate in other media, such as the medium of digital computation. And just as evolution on other planets is not a model of life on Earth, nor is natural evolution in the digital medium (Wilson 352).

"The object of an AL instantiation," Ray wrote, "is to introduce the *natural* form and process of life into an *artificial* medium." The basic idea behind programs like *Tierra* is highly recursive rules that allow complexity to emerge spontaneously as the program runs. The resultant evolutionary creation of "creatures" is not dictated by the programmer; but instead, by the program where outputs are fed back in as inputs resulting in the magnification of small deviations that lead to complex interactions and unexpected evolutionary paths (Hayles 225).

Ray based *Tierra* on "a computer metaphor of organic life" (Ray What). Self-replicating machine code programs are introduced to the computer's RAM memory (Ray Photoessay) where they use an "address by template" technique. Just as DNA matches complementary bases during replication, the *Tierra* program searches for complementary addresses. For example, if the instruction is binary code 1001, the program searches for address 0110. To replicate the evolution of species via mutation, the program flips a bit (between 0 and 1) in memory every

10,000 instructions. Replication errors that occur once every 1,000 to 2,500 instructions also occur (Hayles 226). To clear memory when it becomes full, "[a] 'reaper' function … kills old or defective processes in order to make way for newborn programs" (Ray Photoessay).

To begin the evolutionary process, a portion of memory, analogous to a primordial "soup," is allocated and the program creates an ancestor "creature" or "mother cell" that begins to replicate, creating "daughter cells." As the program executes and mutations occur, not all mutations will be viable. Unexpected results may occur, for example, some "creatures" become parasites and others hyperparasites (Hayles 226-7).

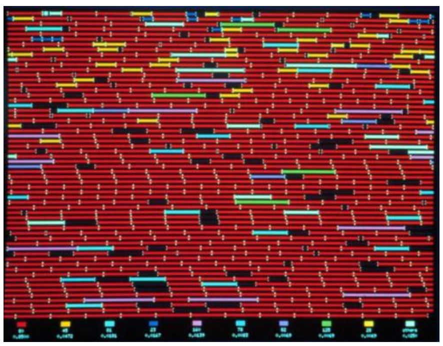
To Ray, the notion of the artist as creator in control is shifted to one of the artist as creator with minimal control. He writes,

> In order to maximally exploit the creative potential of evolution, it is necessary for the human collaborator to give up most of their [sic] control over the process. The human only sets up the environment for evolution to operate in, provides it with raw materials, and then watches as evolution expresses its creativity. This means that the human does not provide any guidance to evolution, and thus can not necessarily expect evolution to produce a useful product. But it is under these conditions that evolution has the maximal freedom to express its own creativity.

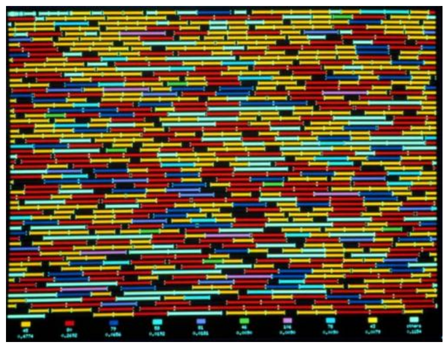
> We do not know yet, if we can ever expect evolution in the digital medium to express a level of creativity comparable to what we have seen in the organic medium (Wilson 354).

Ray collaborated with others to visualize *Tierra* in several ways so that observers could watch the evolution of its “creatures.” The 1998 visualization of *Tierra* is a result of images captured by the Artificial Life Monitor (ALmond) program developed by Marc Cygnus (Ray Photoessay).

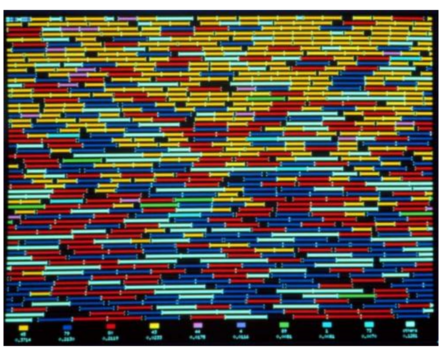
“Tierra” visualization by Thomas Ray and Marc Cyngnus



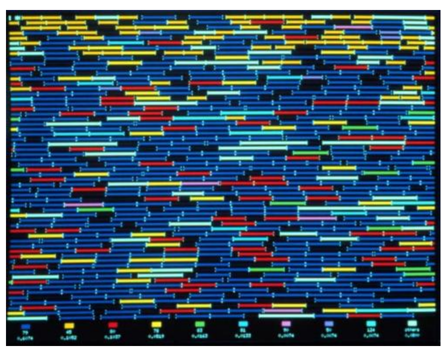
“Hosts, red, are very common. Parasites, yellow, have appeared but are still rare”



“Hosts, are now rare because parasites have become very common. Immune hosts, blue, have appeared but are rare”



“Immune hosts are increasing in frequency, separating the parasites into the top of memory”



“Immune hosts now dominate memory, while parasites and susceptible hosts decline in frequency. The parasites will soon be driven to extinction”

Avida

Christoph Adami is an Artificial Life researcher who looks for life outside of Earth; that is, for biosignatures. A biosignature is any measurable phenomenum that indicates the presence of life – not life as we know it, but Artificial Life; that is, as a set of processes. If we can create a biosignature than we can recognize life somewhere other than Earth without the bias we know to be life (Adami).

Ray's *Tierra* was one of the first true examples of Artificial Life, but it didn't grow in complexity. So, Adami created the system *Avida* which incorporates the complexity *Tierra* lacked. *Avida* is comprised of many strains of virus which are visualized in much the same way as *Tierra* is visualized – each virus is a different color. As the program runs, they grow and spread over each other. Viruses with mutations that make them better fit for survival take over those less fit. Initially strains actively spread and take over other strains; then a steady state is reached. Subsequently a new type of innovation takes over and the strains spread again to a higher level of complexity; this process repeats and repeats (Adami).

But the question is, does this system have a biosignature? Adami says yes; he explains how he constructed a biosignature as a universal process. The building blocks of life, whether organic or inorganic, have their own signature or distribution, just as texts written in different languages each have their own distribution of letters – and these distributions are robust. And so, the viruses in the *Avida* system have a distribution or biosignature that is robust; and, as the environment changes, i.e. the mutation rate changes, the system changes to reflect the environment. For example, when the mutation rate is extremely high, there is no life. But, as the mutation rate falls, the system reaches a threshold where life is possible – the system is alive – and then stasis is reached. As the mutation rate falls to extremely low levels, again there is no life. The *Avida* system shows that if we can "think in terms of processes – then we can start to think about life, not as something that is so special to Earth, but that, in fact, could exist anywhere. It is the concept of information and the process of storing that information within a physical substrate for much longer than you would expect the time scales for the deterioration of information. And if you can do that, then you have life" (Adami).

A-Volve

Both Ray and Adami's Artificial Life evolution systems utilize a process whereby the content of the artwork or research study, respectively, is the result of collaboration between artist, and computer. And just as Ray relinquished his role as sole creator of *Tierra* "to evolution in the digital medium" (Wilson 354), artists Christa Sommerer and Laurent Mignonneau, collaborating with Ray, took it one step further to include the audience in their evolution project, *A-Volve* (1994-1997). To interact with the work, visitors first traced 2-D forms on a touch screen with their fingers which the program then translated into 3-D virtual "creatures" that came alive and swam about in a water-filled glass pool where the process of evolution took place. Those shapes that were better able to swim, mate, and reproduce survived. By placing their hands in the water and interacting with the virtual creatures, visitors were able to influence the creatures movements and behaviors, for example, by pushing them, or placing their hand over them to protect them from being eaten by another creature (Paul 141).

Digital technologies as an artistic medium whereby the work uses the digital platform from production to presentation is aesthetically distinguished as interactive, participatory, dynamic, and customizable (Paul 67). *A-Volve* exhibited all of these characteristics. *A-Volve* was interactive. The complex interplay between visitor and the work was more than merely a mental or point-and-click event; instead, its open-ended 'information narrative' relied on interaction with visitors. The work was participatory as it relied on multi-user input to both create the creatures and influence the process of evolution. As a dynamic art object, *A-Volve* responded to changing data flows in real time as visitors pushed and protected the creatures. And, it was customizable, adapting to each visitor's intervention with the creatures from their creation to control of their survival (Paul68).


"A-Volve" (1994-1997) by Sommerer and Mignonneau

The artists noted, "*A-Volve* literally translates evolutionary rules into the virtual realm and at the same time blends the virtual with the real world" (Sommerer/Mignonneau video). As such, *A-Volve* could be considered a post mechanical technofantasy which incorporated the senses of sight and touch and the phenomenological experience of the image-body where the visitor was placed in the center of the action (Ihde 8-9).

Conclusion

Since the beginning of civilization, artists and scientists have mutually contributed to technologies that communicate visually (Strasberg 206). And, throughout, our bodies have adapted to these different kinds of technologies and technological contexts, beginning with linear perspective and the camera obscura, to photography, the telescope and microscope, to complex visualization software; and those technologies have adapted to us (Ihde 138). In essence, “art and science have been inseparable” (Strasberg 206).

Works Cited

Adami, Christoph. *Finding life we can’t imagine*. *TED.com*. TED Conferences. 2011. Web. 20 Oct 2011. <http://www.ted.com/talks/christophe_adami_finding_life_we_can_t_imagine.html>.

Age of the Sage. *C. P. Snow – Rede Lecture 1959 The Two Cultures and the Scientific Revolution*. N.p. n.d. Web. 3 Nov 2011.

Bly, Adam, ed. “Objectivity and the Image.” *Science is Culture: Conversations at the New Intersection of Science + Society*. New York: Harper Perennial, 2010. 75-88. Print.

Bolter, Jay David. *Writing Space: Computers, Hypertext, and the Remediation of Print*. 2nd ed. New York: Routledge, 2009. Print.

Borzo, Greg. “Scholars, scientists gather to discuss value of ‘the art of science’.” *UChicago News*. The University of Chicago. 12 April 2010. Web. 23 Oct 2011.

Darling, Seth. “Introduction – Artists and their work.” Campus Events by the University of Chicago. 31 (16 Jun 2010). Web. 4 Nov 2011.

De Kruif, Paul. *Microbe Hunters*. San Diego: Harcourt, 1996. Print.

Dyson, George. *The birth of the computer*. *TED.com*. TED Conferences. 2003. Web. 2 Nov 2011.

Fontcubert, Joan. *landscapes without memory*. aperture. Print.

Hayles, N. Katherine. *How We Became PostHuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: U Chicago P, 1999. Print

Hockney, *David. Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*. New and expanded ed. New York:Viking, 2006. Print.

Howells, Richard. *Visual Culture*. Cambridge: Polity, 2010. Print.

Ihde, Don. *Bodies in Technology*. Minneapolis: U Minnesota P, 2002. Print.

"Jean-François Lyotard." *Wikipedia*. 27 Oct. 2011. Web. 20 Nov 2011.

Joshi, Supriya. "Ariel Ruiz i Altaba." Better Photography. Jan 2011. Web. 18 Nov 2011.

Koppes, Steve. "Argonne/UChicago image takes first prize in Visualization Challenge." *UChicago News*. 22 Feb 2011. Web. 4 Nov 2011.

Landow, George P. *Hypertext 3.0: Critical Theory and New Media in an Era of Globalization*. Baltimore: Johns Hopkins UP, 2006. Print.

Levy, Joel. *Scientific Feuds: From Galileo to the Human Genome Project*. London: New Holland, 2010. Print.

Manovich, Lev. *The Language of New Media*. Cambridge: MIT P, 2001. Print.

Markoff, John, “It Started Digital Wheels Turning.” *New York Times*. 7 Nov 2011. Web 7 Nov 2011.

Mitchell, William J. *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*. Cambridge: MIT P, 1992. Print.

Nesbit, Jeff and Colin Norman. “2010 Visualization Challenge.” *Science*. *American Association for the Advancement of Science*. 331 (18 Feb 2011). Web. 4 Nov 2011.

Noll, A. Michael. *Gaussian Quadratic*. *Compart*. 1 Jun 2011. Web. 4 Nov 2011.

Orthofer, M. A. “Galileo in Hell: Looking for a dialogue between science and art.” *The Complete Review*. III.3 (Aug 2002). Web. 23 Oct 2011.

Paul, Christiane. *Digital Art*. World of Art. 2nd ed. London: Thames & Hudson, 2008. Print. World of Art.

Ray, Tom. *Tierra Photoessay*. N.p. n.d. Web. 3 Nov 2011.

Ray, Tom. *What Tierra Is*. N.p. n.d. Web. 3 Nov 2011.

Ruiz i Altaba, Ariel. "Embryonic Landscapes." *Ariel Ruiz i Altaba Studio*. 2006. Web. 18 Nov 2011.

Ruiz i Altaba, Ariel. "Minimal Landscapes." *Ariel Ruiz i Altaba Studio*. 2006. Web. 18 Nov 2011.

"Readymades of Marcel Duchamp." *Wikipedia*. 2011. Web. 11 Nov 2011.

Shlain, Leonard. Art & Physics: Parallel Visions in Space, Time, and Light. New York: Harper Perennial, 2007. Print.

Snow, Charles Percy. *The Two Cultures*. Cambridge: Cambridge U P, 1993. *Google books*. Web. 23 Oct 2011.

Sommerer, Christa, and Laurent Megnonneau. "Sommerer/Megnonneau A-Volve". *Media Art Net*. n.d. Web. 4 Nov 2011.

Sommerer, Christa, and Laurent Megnonneau. *Sommerer/Megnonneau A-Volve*. Video. 4 Nov 2011. <http://www.youtube.com/watch?v=cZ3v1jcCXmk>.

Sorensen, Vibeke. "The Contribution of the Artist to Scientific Visualization." Jet Propulsion Laboratory, Pasadena, CA. 1987. Web. 4 Nov 2011. <http://visualmusic.org/text/scivi1.html>.

Strosberg, Eliane. *Art and Science*. New York: Abbeville, 2001. Print.

Teller, Edward. "Science and Morality." *Science*. 280.5367 (22 May 1998): 1200-1201. 23 Oct 2011. Web.

"Web 2.0." *Wikipedia*. 2011. Web. 17 Nov 2011.

Wilson, Stephen. *Information Arts: Intersections of Art, Science, and Technology*. Cambridge: MIT, 2003. Print.