VISUAL TECHNOLOGIES, COSMOGRAPHIES, AND OUR SENSE OF PLACE IN THE UNIVERSE

by Thomas Rockwell

Abstract. The first part of this paper surveys the visual technologies that have transformed the modern visual environment and argues for the relevance of their study to an understanding of modernity in general and to the field of religion and science in particular. The term *cosmography* is adopted for the visual and spatial manifestation of a worldview, and the importance of analyzing and advancing modern cosmography is asserted. In the second part, the focus shifts to one particular challenge presented by modern cosmography: how to represent and find visual meaning in the new range of size scales that have been offered up by the modern scientific worldview. Six strategies for representing and finding meaning in this new expanded picture of the universe are explored.

Keywords: cosmography; iconography; representation of size scales; visual culture; visual technologies.

VISUAL TECHNOLOGIES, VISUAL CULTURE, AND THEIR RELEVANCE TO SCIENCE AND RELIGION

Developments in visual technologies since the European Renaissance have radically changed our sense of place in the universe. Telescopes, microscopes, and new technologies for printing and displaying images have profoundly altered the visual and conceptual environment in which we conduct our lives. Both the world we see with our eyes open as we navigate through our daily lives and the universe we imagine around us, based on imagery

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from scientific research and popular culture, bear little resemblance to the visual worlds of the past. This changed visual landscape, both actual and imagined, presents a distinctive set of artistic and spiritual challenges for our time. I contend in this paper that one crucial component of the disorientation and alienation so characteristic of the modern age is visual in origin. Unresolved issues of "cosmography," the visual representation of the cosmos and our place within it, make the integration of science into broader aesthetic and religious cultures very difficult. Our ability to feel "at home" in the modern scientific universe is hindered by an incomplete and disorienting revolution in how and what we see.

Visual Technologies and Their Impact. Key players in this revolution are technologies that can be generally described as "visual technologies." These are tools and practices that either produce or reproduce visual information for the human eye. The two classes of visual technologies that are most important to the following discussion are (1) revelatory technologies, which purport to make visible something that is already there, and (2) reproductive technologies, which create copies of visual information and provide a means for their dissemination. Revelatory technologies include the full array of optical microscopes and telescopes that first brought us an expanded universe filled with microorganisms and distant planets; detectors, microscopes, and telescopes that use the full electromagnetic spectrum or beams of electrons to produce images of very small, very distant, or otherwise invisible realms; and experimental or diagnostic apparatus such as mass spectrographs, spark chambers, CAT scans, and magnetic resonance imaging (MRI). Even computerized visualizations of theoretical entities such as mathematical functions or ocean carbon cycles can be said to be revelatory. Reproductive technologies include all forms of printing, combined with the papers, fabrics, and other surfaces onto which images can be transferred. Photography's ability to capture and duplicate light makes it a reproductive technology, and moving-picture technologies such as film, television, and video also fall in this category. Visual software along with cathode ray tubes (CRTs) and other display technologies are also reproductive in that they allow imagery to be broken into analog or digital data and reassembled at remote locations.

The pivotal role played by revelatory visual technologies in the emergence and evolution of modern science has long been recognized. Dutch lens technology in the seventeenth century was a key player in the scientific revolution and led to transformations in visual culture (Alpers 1983). Galileo's telescope, with its resulting image of an imperfect, cratered moon, is repeatedly credited for delivering a final blow to medieval cosmology (Gillispie 1960). Peter Galison has chronicled the changing role in modern science of visual proofs produced by both machines and people (1997; 1998). Regardless of the exact causal role played by these revelatory tech-

nologies (as opposed to the role of their social or intellectual context), the result of their mobilization has been a greatly changed picture of the universe. Thanks to these instruments, a relatively small cosmos of layered earthly and celestial spheres was replaced by a universe filled with incomprehensibly small particles and astounding astronomical distances.

In the same period, reproductive visual technologies ushered in dramatic changes in how information is produced and disseminated. The printing press, although at first primarily disseminating words, did so through a visual medium. With the subsequent invention of photography, moving pictures, and computers, the presence of visual information in culture and society has further increased. Many, across the world, spend a majority of their waking hours immersed in printed pages or in front of CRTs or other screens, while even more wear clothes displaying mass-produced patterns and logos.

In addition to revelatory and reproductive visual technologies, other forms of technological change have profoundly impacted the contemporary visual field. The cultural historian Steven Kern (1983) has shown how the electric light bulb and the railroad changed our sense of space and time. Modern manufacturing and construction technologies, although not explicitly optical, also have profoundly transformed the visual environment experienced by most humans. Concrete and steel landscapes, as well as mass-produced objects and new, "artificial" materials, have altered both what we see in our daily lives and our visual experience of, and distinction between, nature and technology.

The explosive growth of visual information and media in the twentieth century has triggered a wealth of theory and other cultural responses. In his seminal essay "The Work of Art in the Age of Mechanical Reproduction," Walter Benjamin examined how "the very invention of photography had . . . transformed the entire nature of art" ([1936] 1968, 229). Marshall McLuhan's famous maxim "the medium is the message" articulated the power of technology in the formation of culture (1964). Theorists from John Berger (1991) to Donna Haraway (1991) have chronicled the peculiarities of visual meaning in the modern age. Visual concerns have always attracted attention and controversy, as with the iconoclastic controversies of the early Middle Ages. However, the recent growth of new theoretical disciplines, such as semiotics and visual studies (Mirzoeff 1998), and new visual professions, such as graphic design, film making, and computer animation, signal a new centrality of visual culture in modern society.

The influence of visual technology is so pervasive and interwoven in modern culture and daily life that it is easy to forget its power. In the particular case of most revelatory and some reproductive visual technologies, there is something curious about their invisibility or at least transparency. This makes their impact easier to overlook when compared to the impact of classic technologies like planes, trains, and automobiles. We

look through lenses, photographs, and movie screens onto a world beyond, be it real or created. The medium we are looking through disappears, because it's not what we're looking at. The dots of the printed landscape blur into an image of a real place, and the frames of a moving picture blend into a continuous narrative. Even visual technologies that are not transparent, like printed clothes, colorfully pigmented plastics, and ubiquitous television sets, seem relatively benign when compared to the power of atom bombs and genetic engineering. Yet the invisibility of some and the relative friendliness of other visual technologies should not blind us to their cultural impact. It is precisely because they so effectively surround us and fill the "windows of our souls" that these technologies deserve attention when considering modern cultural and spiritual life.

Cosmography and Its Discontents. How, then, are visual technologies and their resulting image cultures significant to culture and spirituality in general and the field of religion and science in particular?

Any worldview, or cosmology, religious or scientific, has a corresponding visual-spatial form, which here will be called its *cosmography*. A cosmography is defined as the set of images, symbols, and models, along with the transmitting media and aesthetics, that define the visual-spatial nature of a particular *cosmology*. Cosmology is used here in its broader meaning to encompass the entire worldview of a culture. The history of the arts and the history of religion are filled with examples of cosmographies and their importance to the cultures that produced them. Many cultures pour enormous creative and material resources into the visualization of their cosmographies. Buddhist mandala paintings and rock-cut temples model in elaborate detail a heavenly architecture and its relation to the worldly plane. The cathedrals and frescoes of Medieval and Renaissance Christianity offer a visual encyclopedia of the cosmos. Dante's *Divine Comedy* and the many paintings inspired by it present a spatial model of a layered world of heaven, purgatory, and hell. Such pioneers as Masaccio and Piero della Francesca employed the geometry of the vanishing point to symbolize an ordered universe centered around the figure of Christ. The geography of exile and return in the Hebrew Bible remains to this day a potent source of religious passion.

Cosmographies not only offer a map of the cosmos but also label and give visual form through icons and symbols to cosmic entities and values that define a religion. Controversies over idolatry in the Old Testament and over the worship of icons during the medieval iconoclastic schisms point to the passions evoked by imagery. The Islamic prohibition of the visual representation of people and deities and the proliferation of medieval Christian bestiaries in manuscripts and churches reflect contrasting responses to a common human urge to capture, in visual terms, the cosmic cast of characters.

Cosmic maps and icons are important elements of most, and arguably all, belief systems. I would go further and suggest that, due to the nature of our existence in space and our powerful visual information processing abilities, cosmographies are an irreducible element of our existential orientation. We live in space and process our environment visually, so it stands to reason that our ultimate beliefs will have a visual-spatial component that functions at least somewhat independently from other media. The particular culture and logic of visual representations has been the focus of much scholarship in art history (Gombrich 2000; Alpers 1983), cultural studies (Berger 1991; Haraway 1991), and cognitive science (Gardner 1993). It is notable that even the proponents of a scientific theory of consciousness have named visual awareness as the starting point for their project (Crick 1995). It can be argued that, given the centrality of vision in human consciousness, spiritual experience must also have a visual dimension that is not reducible to verbal-logical treatment.

Cosmography is one essential component of that visual-spiritual dimension, and it is modern cosmography, based on the scientific worldview and visual technologies, that is the subject of this paper. I contend that several significant cultural and science-religion tensions are operating at this visual, cosmographic level. The image culture spawned by the modern age is aggressive and incomplete, young, and extremely complex in ways that contribute to overstimulation, disorientation, and alienation. Progress toward resolving these tensions in the visual realm, where they originate, will be a valuable contribution to the integration of religion and science.

The particular value of visual thought and aesthetics to the current theological project of integrating religion and science can be illustrated by reference to a recent edition of *Zygon*. In the December 2001 issue of this journal, two separate authors use visual, cosmographic language. Marc Bekoff argues for the creation of a "soulscape—in which to live in harmony with all of our kin, other life and inanimate landscapes" (2001, 649). Maurice K. D. Schouten opens his paper by stating that the top-down, "scholastic picture of a ladder of reality, a *scala universi* (universal scale)" has been replaced by the inverted, bottom-up model of modern reductionism (2001, 679). Both of these quotes display a reliance on visual logic, the first with its appeal to the global and unifying implications of the word land*scape* and the second with its reference to visual hierarchies. While these images can remain as undeveloped metaphors from which to launch a verbal analysis, they also suggest the value of an extended analysis in visual terms. Such an analysis would ask, for example, how to visually represent a "soulscape" or whether debates about reductionism might be advanced by a horizontal realignment of the "ladder of reality," in which neither the top nor the bottom is given priority.

The value of such visual-theological considerations becomes all the more significant when one considers the power of imagery to popularize ideas

and values. The way in which science is visually represented will impact its popular reception as well as its perceived spiritual implications. A successful cosmographic program could help integrate science into contemporary religious and popular cultures. There are, however, several challenges to such a program. The first is the disorientation and alienation produced by the rapidly changing and highly stimulating modern visual environment. Visual technologies and consumer capitalism present a sensory experience and visual value system in which it is difficult to establish and build noncommercial meaning. The sheer quantity, variety, and intensity of imagery and visual technology presents a daunting obstacle to any attempt to identify and nurture cosmographic meaning. The billboards, magazines, televisions, books, movies, and printed fabrics that together make up "popular culture," as well as the art galleries, museums, and niche publications that can be labeled as "high culture," present a bewildering array of material through which to navigate. The problems of visual "information overload" are widely acknowledged (Wurman 1989; Sume, Leifer, and Wurman 2000) and present a challenge for those who wish to build a spiritual understanding of scientific information.

The second challenge to a cosmographic project is inherent in the content and methodology of modern science. The content of science offers a radically altered and counterintuitive world picture in which humans have to struggle to see their reflection and to find a home. A universe that ranges in size from 10^{-36} to 10^{25} meters is difficult enough to imagine. The quantity of subatomic, atomic, and molecular entities, as well as new and expanding botanical and zoological taxonomies, biogeochemical systems, and remote astronomical phenomena that populate this new cosmic landscape is mind-boggling. The counterintuitive nature of the spatial model at the farther reaches of creation only adds to the challenge: curved spacetime, dark matter, quantum particles, and possible hidden dimensions make it difficult to visualize the whole of creation, let alone our place within it.

Furthermore, scientific methodologies, with their emphasis on objective detachment over poetic interpretation, can undercut creative attempts to sustain a metaphorical and spiritual relationship with the material. The professional specialization of scientific subdisciplines means that few are trained to study and communicate the big picture, especially in artistic terms. Also, the suppression of anthropomorphic metaphors in the scientific picture makes the new image of the universe appear cold and alienating to many. Throughout cultural history, humans have sought and imagined the presence of humanlike, or even just animal-like, deities and other beings. Yet science has depicted a landscape almost devoid of our own reflection. Most early cosmographies were created by painters, poets, and prophets, whose introspective and creative methods led to recognizable, humanoid forms of ultimate meaning. Scientific methodologies, by

contrast, have produced a picture that, at first glance at least, is jarring to the aesthetic and existential instincts of many artists.

Developing an image culture that addresses these modern cosmographic challenges is an ambitious undertaking. Such a project is likely to take place over several generations and always remain a work in progress. The creation of this new cosmography has been underway since the scientific revolution, yet much of the specific work to be undertaken has only recently come into focus. The remainder of this paper addresses one particular aspect of this project: the challenge posed by the visual representation and experience of the *size scales* of the universe and its parts.

Six Proposals for How to Experience or Represent the Size Scales of the Universe

The breathtaking expansion of size scales at both the micro and macro levels brought on by the scientific revolution poses an important problem of spatial conception and visualization. The questions addressed in this part are the following: How can a culturally engaged person, whether a scientist, a painter, or even just someone curious about nature, visualize the whole of creation and his or her place within it? What imagery and technologies, what visual maps or practices, can be used to contemplate, however incompletely, both the magnitude and the microscopic complexity of the whole? Most important, how can such an individual locate the human body and human meaning in this big picture?

This problem may not trouble the proverbial man or woman on the street, and, for that matter, it receives little attention from most artists and intellectuals. And yet the problem hinders progress in making science spiritually accessible. Every science fiction movie in which spaceships shoot through a starscape and every magazine article about microscopic biological or chemical hazards remind us of the almost incomprehensibly large and detailed landscape we live in. Yet this landscape, as a whole picture to be depicted, contemplated, and probed for meaning, does not seem to attract much attention. Partly this is because it is inherently difficult to grasp. Partly it is because many intellectuals have grown wary of grand, encyclopedic visions. To many poststructuralist critics such overarching visions are politically suspect "god-tricks" (Haraway 1991, 188). Yet the continued success of science and visual technologies in the construction of a global picture of interconnected size scales begs for integration into aesthetic and spiritual discourses.

In what follows, I outline six responses to the challenge of making visual sense of the size scales of the universe. Although stated as proposals, each of these sections should be considered a creative exploration. They represent an attempt to capture the complexity of choices presented by visual technologies. They range from reactive, almost Luddite responses to sci-fi,

technological fantasies. Together they outline the scope of possible responses, ranging from least technological to most high-tech, to the challenge of comprehending the size scales of the universe.

1. Develop a Practice of Abstinence from Visual Media. Abstinence, whether from food, sexual relations, or even some forms of technology, is a component of most religious traditions. Monastic celibacy, ritual fasting, or the Amish rejection of certain technologies are but a few examples. It is interesting to note that in this age of visual information, various forms of visual abstinence have become common. Laws prohibiting billboards keep the state of Vermont looking pristine, and nature preserves and national parks provide places where people can go and cleanse their retinae of human-made cityscapes. The bumper-sticker slogan "Kill Your Television" is a statement of choice to embrace a slower and simpler visual world. Most antipornography legislation is an attempt to restrict what is considered to be visual pollution. Each of these movements is an attempt to simplify and/or limit a certain form of visual stimulation. They all tell us something about our longings for simplicity in this age of information overload.

Consider the following, far more radical form of visual abstinence. Consider the voluntary choice to spend a set amount of time, say, a day or a week, without reading, using a computer, looking at photographs, or watching television or movies. This idea is based on an exercise proposed by Julia Cameron in *The Artist's Way* (Cameron and Bryan 1992). The motto for this practice could be stated as "Put your eyes where your body is." The goal is to temporarily heighten one's connection to one's actual location in space and time by abstaining from all forms of visual "virtual" reality. In a simple form of this practice, one would still live at home, drive a car, and read road signs and food packaging. One could choose to go further and abstain from the visual effects of "artificial" (I use this word fully aware of its limitations) transportation, shelter, and human infrastructure.

The purpose of such a practice of ritual abstinence would be to anchor one's self in a simple experience of human scale. One of the remarkable things about the human imagination is its ability to be transported by photographs, verbal descriptions, and films. Long before computers, these media offered what could be termed "virtual realities." Humans can usher in another world through their eyes and ears and in some way leave their bodies and immediate surroundings. The explosion of visual technologies has made it possible to spend a majority of one's waking hours looking at pages or screens that take one away from immediate physical reality. Paradoxically, by periodically cleansing one's eyes of the imaginary world of a book or the distant scene of an image of a supernova explosion, one's sense of connection to the greater cosmos can increase. A strong foundation in

real space and real time can make it more rewarding to eventually return to the fantastic visions provided by the Hubble telescope or an electron microscope. It is easier to feel at home in the universe if one is at home in one's own neighborhood.

2. Develop a Two-Dimensional Iconography for the Whole. The abstinence proposed above could be characterized as reactionary, some might say antitechnological, in spirit. My next proposal is essentially technology neutral, in that it addresses the basic symbolic geometry used to represent the set of all size scales of the universe in any two-dimensional (2D) medium. What follows is a proposal to expand the graphic conventions used to map and classify the range of objects in the universe. Experimentation with the form used to chart the full range of creation, be it a single bar graph, orthogonal grid, circular mandala, or spiral, can increase the ability of such an image to function as an object for contemplation.

Many introductory science textbooks begin with a graph composed of a single bar that places the objects in the universe on an exponential scale. Using metric units, each step of the bar graph indicates a higher power of 10 meters. Representations of selected objects of the universal bestiary from quarks (10^{-16} meters) to galactic superclusters (10^{24} meters) are arrayed along this chart. This is the most common 2D convention for representing the size scales of the universe. It is simple and compact, yet, because of the unpoetic use of graphics favored by textbooks, it is rarely memorable or inspiring of contemplation. Furthermore, the compression of what is an exponential growth in size into a linear graph flattens out astounding differences in scale that are being represented. Given the centrality of this "ladder of scale" to the new cosmology, its visual portrayal could benefit from an ongoing artistic experimentation in order to generate new and compelling representations.

The linear representation alone, the single ladder of classification, can be significantly improved. Illustrations could celebrate the metaphor of the ladder or adopt other spatial metaphors such as stairs or many-storied buildings to represent the exponential "powers of ten" classification. The techniques of perspectival representation could be added to the image to imply a greater sense of depth. A simple ladder, for example, could disappear toward a distant vanishing point at either the top or the bottom of the view, depending on the frame of reference. A top-down view, in which each rung appears narrower as the viewer looks down the ladder, would suggest the shrinking size represented by progressively lower steps. Perspective could also be used to imply a distinctly human point of view. Like a view through a fish-eye lens, the ladder could appear widest at the most accessible scales of human experience (from 1 millimeter to 1 kilometer) and then shrink down toward two vanishing points, one at each end, representing the micro and macro edges of scientific knowledge.

There are other graphic geometries that might be more powerful than a single bar graph. A series of postcardlike snapshots of different scales can be arrayed in an orthogonal grid (Morrison, Morrison, and Eames 1982). Cosmographic maps have often favored a circular form. Mandalas, domes, and semicircular tympana over cathedral doors have been commonly used to represent cosmic maps. This preference comes from the fact that, at any instant in time, space is experienced as a spherical volume centered around the viewer. Hence, spherical/circular (or semicircular) representations of the totality of space feel true to subjective experience. The progressive powers of ten could be arrayed in a series of nested circles, like the growth rings of a tree. A spiral can also be used to wrap the sequence of exponential size units around a central focal point. This is the strategy I have adopted for a poster illustration created to represent the ladder of scale (Rockwell 2002).

The purpose of these reflections is not to argue for the superiority of one geometric convention over another but rather to point toward the range of strategies that could be explored. The image of a cosmos made up of a series of nested exponential size scales is central enough to modern cosmography that it merits the kind of artistic experimentation that past cosmographies have benefited from. Through repeated creative reinterpretation by subsequent generations of artists and designers, such images could become more integrated in the public visual consciousness. Whether rendered with old technologies, such as painting or mosaics, or new forms of computer-generated imagery, shared public cosmographic conventions could help viewers locate themselves within a map of the "big picture."

3. *Create Sacred Spaces for the Contemplation of the Ladder of Scale.* Just as the last proposal can be actualized using old or new technologies, so can this next one. The difference is that while the last proposal was limited to 2D representations, the following proposal addresses the creation of contemplative three-dimensional (3D) spaces. Sacred, iconic buildings or parks are a natural medium in which to express a culture's cosmography. Temples, museums, or even just observatories, from Stonehenge to Chartres to the new Rose Center for Earth and Space in New York City, can function as metaphorical representations of the universe. Some, such as Stonehenge or the outdoor observatories built by the maharaja of Jaipur in the eighteenth century, are cosmographic by virtue of their astronomical alignment. Others, such as Gothic cathedrals, represent intentional monuments to the scale and complexity of divine creation.

There are currently two common venues for an explicit architectural representation of the cosmos in our culture: churches of established religions and science museums. These are both public, monumental spaces that at least occasionally attempt to capture some aspect of the whole universe. Both have their limitations. Churches have been slow to integrate

new cosmographic images and are held back by older artistic iconographic traditions. Science museums, on the other hand, lack an explicitly spiritual or even just contemplative mission. Because of their competition for leisure and entertainment dollars they often fall prey to overstimulating design tactics.

This project is also hindered by the particular aesthetic values of twentieth-century modernist architecture. The majority of iconic buildings of the last century embody the modernist disavowal of representational decoration. The success of both science and technology has contributed to this aesthetic. Science, with its vision of a universe cleansed of anthropomorphic forms and governed by mathematical laws, reinforced the value placed on pure geometrical forms. Whereas much premodern architecture and design included the human body and other representations, architects such as Walter Gropius and painters such as Piet Mondriaan launched a program of idealized geometrical abstraction. Advances in technology also made buildings celebrations of their functional structure. The structural simplicity of steel and concrete as well as the intricacies of mechanical systems are often celebrated in modernist architecture. But representational sculpture, painted narratives, and cosmic maps, so dominant in iconic architecture of premodern traditions, have become extremely unfashionable. Even deconstructivist innovators such as Peter Eisenmann and Rem Koolhaas, while rejecting pure Cartesian geometry, still avoid the human form and any explicitly cosmographic decorative program.

New York City is home to two interesting counterexamples to this antirepresentational trend, one based on the Gothic architectural tradition and the other firmly rooted in modernism. The Cathedral of Saint John the Divine has attempted to incorporate scientific symbolism in its ongoing decorative program, thereby maintaining the Gothic ideal of the cathedral as a universal cosmic encyclopedia. One project proposed for the cathedral, which is still under construction, is the creation of a greenhouse symbolic of the earth's ecology on the roof over the nave. The other building, the Rose Center for Earth and Space at the American Museum of Natural History, points to how a cosmographic program might be readmitted to the modernist tradition. In this high-tech building, a 100-foot sphere appears to float inside a cube of glass. The sphere, an icon of the abstract totality of the universe, houses a cutting-edge planetarium and a "Big-Bang Theater." A mezzanine circling the sphere uses a series of comparisons between the sphere and hanging models to demonstrate the ladder of scale. The spiral ramp connecting the bottom of the sphere to the ground floor is a scaled temporal model of astronomical (and some biological) evolution since the Big Bang. At a scale of 10 million years per foot, all of human recorded history is symbolized at the end of the walk by the thickness of a single human hair.

While both of these existing examples are significant, one can imagine a new, rich tradition of cosmographic architecture. This would require either a new form of institutional support or other patronage. Such spaces would differ from science museums in that they would emphasize contemplation over didactic education mixed with entertainment (sometimes called "edu-tainment"). They could be gathering places for prayer and meditation as well as musical and theatrical performances with cosmological content. These could be made of simple materials, like a modern Stonehenge filled with more or less complex sculptural and pictorial images of the ladder of scale; or they could be high-tech environments filled with interactive new media experiences. One can speculate about basic architectural forms that could symbolize the size scales of the universe as well as the epic of evolution. The steps of a structure like an amphitheater could represent the ladder of scale. Pathways through colonnades or parks could visually represent cosmic narratives. Whether such an architecture can emerge from existing religious or educational institutions or whether it will require new, yet to be formed social entities remains to be seen.

4. Experiment with the Artistic and Cosmographic Potential of the Cosmic Zoom Pioneered by the Film Powers of Ten. The most successful visual representation of the size scales of modern cosmography is the film *Powers of Ten* produced by the office of Charles and Ray Eames in 1977 and the accompanying book of the same title by Philip and Phylis Morrison and Ray Eames (1982). The film consists of a long cosmic zoom, from an image of a picnic on Soldier Field in Chicago, all the way to the large-scale structure of the universe, and then back down into the microscopic structures in the hand of the man lying on the picnic blanket. Every ten seconds in the zoom traverses a distance that increases and later decreases by exponential powers of ten meters; as the camera moves, it speeds up (or slows down) by a factor of 10 every ten seconds, and the dimensions of the picture frame grow or shrink proportionally. This film is on permanent display at many science museums throughout the world and is now available in a CD form (Eames Office Production 1999) that allows the viewer to navigate through it at will.

This is the first proposal that inherently relies on a modern technology. The previous proposals can be accomplished without recourse to any modern technologies. Not so the proposal to launch an artistic genre based on the Eames "zoom." The very nature of this image relies on moving picture technology combined with the optics of moving lenses. Because of photographic zoom lenses and their use in film and television, zooming images have become a familiar feature of modern visual culture. Having become a common cinematographic technique, zooms have come to symbolize everything from rapid space travel to heightened dramatic intensity. They also inherently lend themselves to an accessible exploration of size scales.

There are many ways that the cosmic zoom pioneered by Charles and Ray Eames could be reinterpreted, making it a founding precursor to a whole cosmographic genre. The zoom itself was inspired by an earlier book by the Dutch schoolteacher Kees Boeke (1957) and has already been reinterpreted by computer generated shows in several planetaria in science and natural history museums. This suggests the beginning of a creative form, like the sonnet or sonata, defined in this case as any zooming tour of the universe. As the form becomes more familiar, artists will be able to experiment with its poetic potential. While the text of *Powers of Ten* narrated by Philip Morrison is educational and the background music is very simple, later versions of this form might experiment with more poetic text and more sophisticated music. The images themselves might also be more poetic or meaningful, especially at the human scale. The time frame could be modified to give more expanded coverage of the human scale where love, hatred, joy, and fear, which concern most people, take place. One can imagine moving from a moment of powerful human drama into images of the dance of neurotransmitters underlying such a moment or the intergalactic landscape upon which the drama takes place.

5. Create and Maintain a Database through Which Viewers Can Tour 3D Virtual Models of the Universe and Its Parts. This next proposal, although currently technologically feasible in rudimentary form, would require significant investment and innovation for its most ambitious realization. Taking *Powers of Ten* several technological steps further would involve the creation of a computerized 3D database through which a viewer could navigate at will. She or he would be able to zoom between size scales and move between different views of the same size scale. In its simplest form this would be like already existing virtual reality environments, with an expanded range of scale in which one could zoom all the way from quarks to quasars. Existing software for video games, architectural rendering, and computer animation, along with 3D databases of molecular shapes and ecological or astronomical simulations, would provide valuable resources for such a project.

The project is most ambitious in its overall scale. The goal would be to create flexible enough data standards and storage capacity to allow access to 3D digital representations of a significant range of objects in the universe. Some central entity, such as UNESCO, NASA, or the National Science Foundation, could screen, host, and update these data based on contributions from researchers and computer graphics artists around the world. This central host could then provide public access to the data via the Internet. In its ideal and somewhat sci-fi form, this central database and server would be able to transfer real-time animations based on the visitor's commands. For example, a joy stick or cursor would allow a remote visitor to zoom up and down and move laterally or rotationally within

a given size scale in real time or close to it. The necessary software, computational power, and bandwidth, as well as screening and updating the data, would require substantial institutional and financial support.

This would be a 3D public encyclopedia, accessible to anyone over the Internet. It would be a digital monument that displayed the full scope of the new cosmography. It could function as a tool for research and a vehicle for publication of new data, and it could even become a resource for commercial entertainment. High school and advanced researchers could access 3D data about microbiology, geography, or astronomy. New scientific data, say in molecular biology, neuroanatomy, or astrophysical cosmology, could be published directly through this medium. Even if this were never to be realized, simply imagining the existence of such a multimedia encyclopedia provokes some interesting questions. How would the debate between reductionists and proponents of emergent phenomena be affected by such a hypothetical technology? Could it lead to the discovery of new size-dependent phenomena or laws? Would experiential, albeit virtual, familiarity with switching size scales eventually lead to an improved sense of belonging to the universe? Even if the experience were initially daunting and disorienting, it could provide a means to inhabit and explore our new cosmography that could lead to new scientific, humanistic, or theological insights.

6. Contemplate Extreme Forms of Future Visual Technologies. This last proposal belongs in the category of speculative science fiction. The following thought experiment assumes that, with genetic engineering, artificial intelligence, and robotics growing at exponential rates, new and more radical innovations in visual technologies will become possible. For example, genetically or surgically altered human vision could be in our future, as well as conscious robots that can see more and better than humans. Our goal here is to entertain some of these advanced scenarios, not because they are necessary or even desirable but rather for what they can reveal about visual ambitions and the nature of consciousness itself.

Many possible innovations in visual technology can be imagined. Modifying the molecules of the human retina could allow for an increased range of vision into infrared and ultraviolet spectra. Alterations to the cornea, possibly introducing more lenses, could offer the promise of a telescopic and microscopic range of vision. Individuals with such "built in" visual abilities would make great scientists, detectives, or soldiers.

Even more dramatic changes can be imagined that would allow humans or robots to transcend the limitations of place and scale. Imagine, for example, a brain or artificial intelligence that integrates visual data supplied by wireless technology from multiple and remote sources or size scales. The human body is already a distributed consciousness involving the coordination and integration of many data entry points. However, our eyes

in particular still create a strong experience of consciousness in which information converges toward a single point of view. It is possible, however, to imagine a single, integrated consciousness fed by multiple "eyes" spread across the universe. In a sense, our visual memory already makes this possible as we juxtapose and integrate multiple remembered or constructed images.

To consider such a supercyborg is to imagine a single being that could incorporate in one consciousness the information that is currently distributed among many minds and instruments across many different visual disciplines. Contemplating such a consciousness could be alternately disorienting or enlightening. Would such enhanced vision induce madness, reveal greater truths, or just provide a more complex visual backdrop on which familiar dramas of consciousness are played out? Would the ability to simultaneously experience the full range of microscopic and large-scale visions of the same phenomenon free one from confusion about the priority of reductive versus emergent perspectives? Could contemplating an extreme form of this enhanced vision lead to useful reflections about divine omniscience?

Attempting to answer these questions falls beyond the scope of this paper and would be limited by their highly speculative nature. The goal of such fantastic speculation, however, is to shed light on technological (and epistemological) values, hopes, and fears. Will a future of extended human vision just breed visual greed and arrogance or provoke greater insight into the nature of the universe? As with the interpretation of most technological innovation, both pessimistic and optimistic reactions can be found. Donna Haraway typifies a pessimistic stance toward such universal visual ambitions in characteristically colorful prose:

> Vision in the technological feast becomes unregulated gluttony; all perspective gives way to infinitely mobile vision, which no longer seems just mythically about the god-trick of seeing everything from nowhere, but to have put the myth into ordinary practice. And like the god-trick, this eye f***s the world to make technomonsters. Zoe Sofoulis (1988) calls this the cannibal-eye of masculinist, extraterrestrial projects for excremental second birthing. (1991, 188)

On the other hand, the astrophysicist John Barrow paints a more optimistic view of human sensory and aesthetic consciousness in his book *The Artful Universe*:

> We have instincts and propensities that bear subtle testimony to the universalities of our own environment, and that of our distant ancestors. . . . Some of those environmental universalities stretch farther out than our home planet. They reflect the regularities of solar systems, galaxies, and our home planet. They may tell us important things about any form of living intelligence—wherever it might be in the Universe. (1995, 2)

If, as Barrow believes, visual intelligence coevolved in relation to universal constraints, expanded visual skills would only increase our experience

of harmony with the universe itself. Yet an evolutionary argument also can be made to support Haraway's pessimism, focusing on the selectively successful, but epistemologically arrogant, selfishness and greed of our perceptual ambitions. Such polarized assessments of our cognitive ambitions suggest the need for caution and humility. Yet it is also tempting to embrace the hopeful prospect that we might discover our senses and consciousness to be not a cosmic anomaly but, in the words of Stuart Kauffman, "at home in the Universe" (1996).

Conclusion

The goal of this paper has been to identify a class of technological change with powerful cultural consequences and particular relevance to the project of integrating religion and science. In my focus on visual technologies in general, and on the representation of size scales in particular, I have tried to establish the relevance of cosmographic work. Six proposals were chosen to represent the breadth of possible applied responses to a particular cosmographic challenge. These range from technological abstinence to speculations about extreme technological change. Together, these proposals consist of an artistic-spiritual-technological program for building cosmographic meaning out of data about the size scales of the universe. The contrasting quotations from Haraway and Barrow indicate the extent to which such a program can elicit opposite responses. I personally find myself closer to Barrow's optimism about the prospect for increased aesthetic connection with the universe. Yet, I share some concerns with Haraway about the dangers of such a universalist project. Our new cosmography is young and in the throes of a growth spurt; and, like an adolescent, it needs to mature and grow wise about its subjective limits. It is my hope that artistic explorations of this new cosmography may render it more accessible and at the same time celebrate its roots in human subjective consciousness.

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