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AXIOM
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Master of Fine Arts in Visual Communication Design
School of Design | College of Imaging Arts and Sciences

Rochester Institute of Technology
December 6, 2013
Axiom: A short film, utilizing 3D computer animation in conjunction with live-action video, that puts a technological twist on the Greek myth of Persephone

by Jon Fila & Peter Klinkon

A Thesis submitted to the Faculty of the College of Imaging Arts and Sciences in candidacy for the degree of Master of Fine Arts
Computer Graphics Design

December 10, 2013
Axiom
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June 12, 2013

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Abstract

Axiom is a short narrative video, using live-action and 3D computer graphics to re-interpret the Greek myth of Persephone through the framework of contemporary science-fiction. The aim of the video is to use narrative, approached from a design strategy that thematizes the representational role of 3D computer generated graphics, to raise questions in the minds of thoughtful viewers about the use of genetics and computer simulated worlds in the context of the vulnerable natural environment. The conceptualization of the video is explained, followed by a summary of the production pipeline, and finally an evaluation of the finished piece.

Design Problems

This project is a response to the problems arising from the use of computers in the design of an experience that reflects (and refracts) the possible uses of emergent imaging technologies and its effects on the biological environment. The problems encountered in conceptualizing the design of such an experience emerge from a discussion of the way computer graphic technology exists in its current environment.

i) Computers and Graphics

Approaching the problems involved in the design of computer graphics opens up some large questions that can be answered with various strategies. Design problems associated with the use of computers covers the gamut of issues that crop up in the rendering of any visual form, however, the use of the computer itself brings other issues along with it. The issues specific to the use of computers generally, and even technology more broadly, is still and always will be evolving. The way technology functions is under constant re-definition by society as we invent new tools and discover various uses for them. The way we use technology becomes the definition of technology: the problems it helps solve and the new problems it helps create. The conflicts technology becomes involved in help form its identity, which has become unclear under the rapid development it has seen over the last couple centuries. Technology, especially in its late accelerated developments, has become a cause of both
great optimism and considerable anxiety. The problem of technology's identity includes the general
issues of representation, as images necessarily require some type of technical execution to become
shared actuality. It seems appropriate to look at how current computer technology can be applied to
the issues of image-making in order to approach the larger issues posed by technology.

Computer Graphics, as its name implies, utilizes primarily symbol manipulation technology
to manifest visible images in the natural world. However, human culture has created a semiotic
distinction between itself and its environment, based on the intentionality it attributes to its own
actions and not to its environment. When human intentionality appropriates its environment and
manipulates it to take a usable form, the isolated and manipulated environment becomes a tool to
perform further functions upon nature and culture alike: a saw can cut down a tree, a trowel can help
plant a new one, and paint applied to a brush allows the representation of a tree within the cultural
field. Although usually considered an artificial phenomenon, technology is clearly a bridge between
these semiotic poles. The challenge for Computer Graphics, as a cultural means of representation,
is then to demonstrate the integral role technology plays in linking culture to nature. Computer
Graphics can help clarify its own identity and value, beyond an illusion of self-sustaining virtuality, by
placing itself at the conjunction of consciousness and environment.

Of course the question of the relationship between consciousness and its environment has
been inconclusively debated for as long as human memory goes back (aided by the technological
invention of writing). Language, a set of phonetic and graphic symbols manifested in the
environment, created the semiotic splits in human psychological reality, but at the same time sutured
the binaries with the very linguistic structure that created the split in the first place (as Lacanian
psychoanalytic theory would put it—e.g. see chapter 5 of Kaja Silverman, The Subject of Semiotics
(New York: Oxford University Press, 1983).). Since this initiating technological moment, when
humans placed representations in the environment, technology has grown according to human desire
over and against the natural environment. As culture has evolved and become more aware of its
dependence on nature, the need to use technology in such a way that is respectful of the environment
has become increasingly relevant. Some of the discussion surrounding technology has cast it either as
the cause of environmental deterioration and possible demise or alternately, as the means for human
immortality and independence from the earth. Industrialization has surely done much in the way of harvesting resources faster than they can be replenished and adding pollutants to the environment, making certain areas uninhabitable to ourselves and other living things. At the same time, the pace of medical and construction advances allow humans the ability to live longer and create shelters that may sustain their biological needs, regardless of the environmental conditions. Technology, however, is simply a transformative tool that can be put to work toward any goal, not that the outcome of such technical activity is not complex and open to judgement from various perspectives; the responsibility of freedom applies to the use of technology, not unlike the rest of human activity, and ethics pertains to the environment, including (but not limited to) the other humans within it. The way we choose to use technology establishes a certain relationship with the environment. We select the world we will live in when we define our relationships (in the symbolic substitution of objects). Both in the language that shapes our self-consciousness and in the languages we use to communicate with machines, a unique world is wrapped around objects that are shared with many other self-conscious worlds.

With computers, humans can create representations of the environment that allow for more efficient problem solving through simulation. By creating and testing alternate scenarios, humans may reveal a path toward a mutually satisfying relationship between technological culture and the environment. The causal relations we project and evaluate determine the plot of the narrative we ultimately live. Rather than fall victim to unreflective actualization of technical possibility, we may overcome our fear of technology and gain mastery of our tools when we learn to control them as reflections of the way we represent ourselves and the environment.

Given the role technology plays in framing the visual stories we tell each other and the resulting shift in our perception of the world, the challenge for the graphic application of computer technology is to present a narrative that reveals a world similar to the one we know but with significant difference. It is this difference between the fictional world and the familiar one that reveals the variations possible in reality. The narrative must travel through the path opened by the difference effected by the fiction and explore the possible consequences of the alternative world to fulfill its dialectic function as fiction.
ii) Metagraphics: Style and Content

All graphics are metagraphics in as much as they exhibit assumptions about what they are and how they are meant to function, although some graphics may behave more clearly in this respect than others. The more clearly a graphic exemplifies its metagraphic, the more clearly a viewer will experience the representation. Another way to say this would be that graphics are most successful when the style of representation has a correspondence with the subject— the world pictured is different than the real world, necessitating its explanation through stylized rendering, which betrays its own purpose or use in the real world.

The presence of computers in the unknown possibilities of imminent reality provokes the question: “How can Computer Graphics reflect its role in the world today?” Drawing from the intersection between biological and electronic codes as well as the historical tradition of re-articulating our creation myths, the synthetic power of fiction suggests an answer: to create a world where technology simulates genetic expression and humans adjust the simulation to bring new genetic sequences into the world. Adjust the classical story of Persephone, who is unwillingly bound to the unseen realm of Hades, yet whose cyclical return to the earth coincides with the renewal of vegetation in spring. Render the story so that the theme of digital modification of the world informs the style as much as the story.

iii) Solution: Axiom

To answer the challenge of designing a digital experience that reflects the nature of technology and its relationship to nature, a narrative video, Axiom, uses 3D computer generated graphics in conjunction with live-action footage to reveal one possible world where computers are used to preserve, edit, and replicate the genetic code of botanical life on earth. The narrative assumes that by enframing organic reality with computer technology, the resulting digital information can be simulated, edited, and re-sequenced in organic reality. It supposes human computer interface to be internal to the mind as well as extended by the eye and the hand into the environment. Beginning from these propositions about the role of technology, Axiom demonstrates the creative responsibility
technology holds in constructing the future of the environment—especially when set the task of representing the as-yet-unknown world on the cusp of the present in a symbolic structure and then translating the data to a visualization that humans can optimally interact with. Axiom uses a fictional narrative to illustrate (using computer graphics within a narrative structure) how technology is as variable as the parameters observed and utilized.

By re-coding the Greek myth of Persephone, a prototypical example of the linguistic symbol structure enframing nature, Axiom employs an approach to narrative that mirrors the function of technology. Re-framing an origin myth of the botanical life cycles with a computer-enhanced form of storytelling (language being the initiatory ‘human’ technology), Axiom substitutes the domain of digital information and simulation (a computer system called the Holographic Archival DNA Emulation System, or H.A.D.E.S.) for the Greek realm of the dead (Hades, ruler and kingdom alike) and the goddess of vegetation (Persephone) for the scientist / programmer named Persephone Greenrose.

In the original myth, Persephone, daughter of the goddess of the harvest, is kidnapped while picking wildflowers by Hades, god of the underworld, to be made his wife. Through intervention of her mother and of Zeus, the authority of Olympus, Persephone is permitted to return to the earth for a limited time in spring, bringing life back to plants. Axiom recontextualizes this story into a world similar in appearance to our own, but with manipulated aspects of the myth that emphasize the rendering of genetic technology and simulated environmental interfaces. Axiom’s design decisions about the representation of technology exemplifies the title’s Greek etymological root axioma and proposes ‘what is thought fitting’ for technology to be.

iv) Design Strategy

Designing a visual story for contemporary audiences of science fiction cinema to reflect on the role of emerging technologies requires an overall style to be developed with which the story is articulated. This style informs the various aspects of the design process. The design decisions made in the production process were informed by a stylization that blends the synthetic with the natural. Design decisions were made at each stage of production but were based on a conceptualized strategy
that was worked out in the preproduction and visualization. The strategy was to use 3D computer
graphics to create a virtual link between itself and the natural environment by means of a revision
and recontextualization of an ancient myth about the regenerative relationship between the existing
and the non-existing. The reinterpretation of Persephone's story was reduced and supplemented with
design elements that emphasize the entanglement of human minds, bodies, and technology with the
natural environment that is the unknowably real world. Bearing in mind the literature related to
technology and representation, general filmmaking and animation, and other cinematic treatments
of these themes and myths, a narrative was conceived and visualized over the course of repeated
iterations and revisions, each with increasing levels of detail. The cyclical re-creation of the narrative
during the design process closely resembles the way technology, and especially computer-aided
visual narrative, re-presents input from the world in a new form within the virtual world of human
consciousness.
Review Of Literature

In the conceptualization of Axiom, research was done on the cinematic and literary work that has been done on the subject of computer simulation and its relation to nature, the various renditions of the Persephone's story, as well as on filmmaking and animation workflows.

i) Nature and Simulation

Within the natural world, technology has progressed to the point of simulating natural phenomena. Both the natural world and its simulated relatives are structured on sequences of symbolic information that form procedural rules for handling new information. Whether natural or simulated, worlds express the code that it is made from and acts out. The actual media that the world is made from (i.e. the chemical-electrical bonds between molecules) is itself a code acting itself out. The code conditions its own behavior so as to replicate itself, allowing the world not only to continue, but also to change. The confusion between natural and simulated worlds that results from the discovery of the genetic basis of life and the subatomic makeup of molecules. The rise of information within our awareness of the worlds we perpetuate has left humans nervous and excited about the uncertain relation that technology has with nature. Between Aristotle and Oscar Wilde, the reciprocal mimesis between life and art (an application of technology with its own codes and languages) has been recognized, however since then a more interlaced picture of the technological landscape has been collectively painted.

Martin Heidegger

Even before the explosion in computer processing, three essays written in the latter part of German philosopher Martin Heidegger’s career raise the question of technology’s role in relation to nature. Drawing upon ancient Greek thought, he finds nature to be a common lost object to art and technology alike, both of which continue to peruse nature, nonetheless generating images in its trail that may either bring our knowledge close enough to glimpse this concealed reserve of truth (if even for a moment before it hides in a new form), or else to add to the occlusion of nature by constructed images.
The Origin of the Work of Art (1935-1960)

Heidegger writes that the greek concept of techne, similar to episteme, is a way of revealing nature. Using technical tools like words or machines, humans may uncover knowledge.

“It has often been pointed out that the Greeks, who know a few things about works of art, wise that same word, techne, for craft and art and call the craftsman and the artist by the same name: technites.

“It thus seems advisable to define the essence of creative work in terms of its craft aspect. But reference to the linguistic usage of the Greeks, with their experience of the matter must give us pause. However usual and convincing the reference may be to the Greek practice of naming craft and art by the same name, techne, it nevertheless remains oblique and superficial; for techne signifies neither craft nor art, and not at all the technical in our present-day sense; it never means a kind of practical performance.

“The word techie denotes rather a mode of knowing. To know means to have seen, in the widest sense of seeing, which means to apprehend what is present, as such. For Greek thought the essence of knowing consists in aletheia, that is in the revealing of beings. It supports and guide all comportment toward beings. Techne, as knowledge experienced in the Greek manner, is a bringing forth of beings in that it brings forth what is present as such out of concealedness and specifically into the unconcealedness of their appearance…(Heidegger, Basic, pp.179-180)”

Knowledge is described as the experience of interfacing with nature to summon the information that defines a particular being within it (replace the word ‘object’ for ‘being’ if Heidegger’s primordial animism makes you uncomfortable). The information returned by the nature is expressed in the particular being’s form and behavior, now visible as knowledge (again). Knowledge seems to work similar to a computer program that changes its source code after printing it. The user calls functions to get data returned— blocks of code to be passed back into the program, adding or overwriting the source code of the program, nullifying the boolean truth value of the code that was just returned.

The Question Concerning Technology (1949-1954)

Heidegger questions the common understanding of technology that takes for granted the advances without considering the goals and assumptions built into the functionality of the machines we create. Because the uses of technology have positive or negative effects on different parts of the environment, yet is developed and controlled by self-interested parties, technology is not neutral. The danger presented by technology, beyond the possible negative impact it can have on beings
in the world, is that when acclimated to the values encoded in the technology, beings in the real environment may substitute the machine’s interpretation of the world for an unmediated engagement with environment itself, slippery as it may be to understand. By concealing the essence of the real with the predetermined representation used by the structural methodology, technology forces humanity into deciding which future they want to create.

“The essence of modern technology lies in enframing. Enframing belongs within the destining of revealing. These sentences express something different from the talk that we hear more frequently, to the effect that technology is the fate of our age, where “fate” means the inevitableness of an unalterable course.

“But when we consider the essence of technology we experience enframing as a destining of revealing. In this way we are already sojourning within the open space of destining, a destining that in no way confines us to a stultified compulsion to push on blindly with technology or, what comes to the same, to rebel helplessly against it and curse it as the work of the devil. Quite to the contrary, when we once open ourselves expressly to the essence of technology we find ourselves unexpectedly taken into a freeing claim.

“The essence of technology lies in enframing. Its holding sway belong within destining. Since destining at any given time starts man on a way of revealing, man, thus underway, is continually approaching the brink of the possibility of pursuing and pushing forward nothing but what is revealed in ordering, and of deriving all his standards on this basis. Through this the other possibility is blocked, that man might be admitted more and sooner and ever more primally to the essence of what is unconcealed and to its unconcealment, in order that he might experience as his essence the requisite belonging to revealing.

“Placed between these possibilities, man is endangered by destining. (Heidegger, Basic, p. 307)”

**The Age of the World Picture (1938)**

Modernity, with its technical developments, has turned the world into a picture. The behavior of human society has been tied to feedback from machines. We build machines based on our expectations and demands of nature. If follows that the product of the machine’s work attempts to (and for the most part, succeeds) in effecting a changed state in the environment. Our experience of the environment is then always-already manipulated by technology, mediating its appearance through an interface that is designed to fit into our operational sense of familiarity— at the expense of the experience of the unknown aspect of reality. Understood this way, all technology creates representations, and representation is the essential function of both technology and consciousness.
"That which is, is no longer that which presences; it is rather that which, in representing, is first set over against, that which stands fixedly over against, which has the character of object. Representing is making-stand-over-against, an objectifying that goes forward and masters. In this way representing drives everything together into the unity of that which is thus given the character of object. Representing is coagitation.

"Every relation to something—willing, taking point of view, being sensible of [something]—is already representing; it is cogitans, which we translate as ‘thinking.’ (Heidegger, Question p. 150)"

Every technology behaves in accordance with its inscribed way of thinking the world. New technology generates new ways of seeing and each point of view is a unique world that sets its own representations over the objects in its environment. These represented images generated by technology and consciousness access hidden aspects of the environment. The greater variety of images we generate to understand the environment, the more of it we can know.

Jean Baudrillard, Simulacra and Simulation

For French theorist Jean Baudrillard, the perfection of computer simulation has made the notion of reality impossible. Without a detectable difference between the real and the simulated, authenticity is semantically meaningless. In such an environment, the model of nature precedes its actualization and becomes indistinguishable from it.

“Today abstraction is no longer that of the map, the double, the mirror, or the concept. Simulation is no longer that of a territory, a referential being, or a substance. It is the generation by models of a real without origin or reality: a hyperreal. The territory no longer precedes the map, nor does it survive it. It is nevertheless the map that precedes the territory—precession of simulacra—that engenders the territory, and if one must return to the fable, today it is the territory whose shreds slowly rot across the extent of the map. It is the real, and not the map, whose vestiges persist here and there in the deserts that are no longer those of the Empire, but ours. The desert of the real itself.

"In fact, even inverted, Borge’s fable is unusable. Only the allegory of the Empire, perhaps, remains, Because it is with this same imperialism that present-day simulators attempt to make the real, all of the real, coincide with their models of simulation. But it is no longer a question of either maps or territories. Something has disappeared: the sovereign difference, between one and the other, that constitutes the poetry of the map and the charm of the territory, the magic of the concept and the charm of the real. This imaginary of representation, which simultaneously culminates in and is engulfed by the cartographer’s mad project of the ideal coextensively of map and territory, disappears in the simulation whose operation is nuclear and genetic, no longer at all specular or discursive. It is all of metaphysics
that is lost. No more mirror of being and appearances, of the real and its concept. No more imaginary coextensively: it is genetic miniaturization that is the dimension of simulation. The real is produced from miniaturized cells, matrices, and memory banks, models of control—and it can be reproduced an indefinite number of times from these. It no longer needs to be rational, because it no longer measures itself against either an ideal or negative instance. It is no longer anything but operational. In fact, it is no longer really the real, because to imaginary envelops it anymore. It is a hyperreal produced from a radiating synthesis of combinatorial models in a hyperspace whiteout atmosphere.

“By crossing into a space whose curvature is no longer that of the real, nor that of truth, the era of simulation is inaugurated by a liquidation of all referentials – worse: with their artificial resurrection in the systems of signs, a material more malleable than meaning, in that it lends itself to all systems of equivalences, to all binary oppositions, to all combinatorial algebra. It is no longer a question of substituting the signs of the real for the real, that is to say of a operation of deterring every real process via its operational double, a programmatic, metastable, perfectly descriptive machine that offers all the signs of the real and short-circuits all its vicissitudes. Never again will the real have the chance to produce itself—such is the vital function of the model in a system of death, or rather of anticipated resurrection, that no longer even gives the event of death a chance. A hyperreal henceforth sheltered from the imaginary, and from any distinction between the real and imaginary, leaving room only for the orbital recurrence of models and for the simulated generation of differences. (Baudrillard, pp. 1-3)”

Paul Virilio, Lost Dimension

Media theorist Paul Virilio observes a correlation between technical and cultural developments. In a technologically accelerating culture, time itself approaches disappearance.

The conventions of measurement adopted by science and technology shape the human experience of time as human behaviors adapt to the tools that enable our activity.

“Speaking in an interview about his recent book, Time and Narrative, Paul Ricoeur noted, ‘We are not capable of producing a concept of time that is at once cosmological, biological, historical and individual.’ In this Ricoeur ignores the contributions of science and technology, …

“He also ignores the nature of technological narratives. For example, when the philosopher explains, ‘The activity of the narrative consists in constructing coherent temporal ensembles: in order to configure time,’ he is describing more than the human sciences. In fact, above all else, he is expressing the situation of the exact sciences: the production regimes of temporalities by means of primary and advanced technologies. As already noted, these coherent temporal assemblages contribute to the configuration of space and time, of individual time, of the social time of the history of mentalities, and — first and foremost — the scientific and political time of physics, geophysics and astrophysics. (Virilio, p. 103)”
Virilio is already looking at the environment as an object constructed by technical representations and inflected by the systems of measurement that were invented by social convention, but are being re-articulated as technological development anticipates the singularity of its independence.

Nelson Goodman, *Ways of Worldmaking*

“We can have words without a world but no world without words or other symbols...Worldmaking as we know it always starts from worlds already on hand; the making is a remaking.” Nelson Goodman, an American philosopher, sees the relativism that rises out of a recognition of multiple perspectives as an opportunity to tailor the truth of a representation, which is by extension a world with its own worldview or way of seeing. He outlines the fundamental ways of world making including: composition, weighting, ordering, deletion, supplementation, and deformation.

“Fiction, then, whether written or painted or acted, applies truly neither to nothing nor to diaphanous possible worlds but, albeit metaphorically, to actual worlds. Somewhat as I have argued elsewhere that the merely possible — sofar as admissible at all— lies within the actual, so we might say here again, in a different context, that the so-called possible worlds of fiction lie within actual worlds. Fiction operates in actual worlds in mush the same way as nonfiction. Cervantes and Bosch and Goya, no less than Boswell and Newton and Darwin, take and unmake and remake familiar worlds, recasting them in remarkable and sometimes recondite but eventually recognizable—that is re-cognizable—ways....”

“Nondescriptive, nonrepresentational works nevertheless function as symbols for features they posses either literally or metaphorically. Serving as samples of, and thereby focussing attention upon, certain— often upon unnoticed or neglected— shared or shareable forms, colors, feelings, such works induce reorganization of our accustomed world in accordance with these features, thus dividing and combining erstwhile relevant kinds, adding and subtracting, effecting new discriminations and integrations, reordering priorities. Indeed, symbols may work through exemplification and expression as well as through denotation in any or all of the various already mentioned ways of world making....”

“Exemplification and exression are of course functions not of abstract works exclusively but also of many descriptive and representational works, fictional and nonfictional...”But whether alone or in combination, the several modes and means of symbolization are powerful instruments.”… “The artist’s resources—modes of reference, literal and nonliteral, linguistic and nonlinguistic, denotational and non-denotational, in many media—seem more varied and impressive that the scientist’s. But to suppose that science is flatfootedly linguistic, literal, and denotational would be to overlook, for instance, the analog instruments often used, the metaphor involved in measurement when a numerical scheme is applied in a new realm, and the talk in current physics and astronomy of charm and strangeness and black holes. Even if the ultimate product of science, unlike that of art, is a literal,
verbal or mathematical, denotational theory, science and art proceed in much the same way with their searching and building. (Goodman, pp. 104-107)"

Goodman holds the cognitive process of symbolic simulation as the very basis of the possibility of interaction between consciousness and the world it occurs in. But the world depends on the activity of consciousness for its continued appearance, which is being re-simulated at every moment, by every discrete node of intelligence within it.

“If worlds are as much made as found, so also knowing is as much remaking as repairing. All the processes of world making I have discussed enter into knowing. Perceiving motion, we have seen, often consists in producing it. Discovering laws involves drafting them. Recognizing patterns is very much a matter of inventing and imposing them. Comprehension and creation go on together. (Goodman, p.22)"

Ray Kurzweil, The Age of Intelligent Machines

Inventor Ray Kurzweil is an optimistic futurist who advocates the rapid development of artificial intelligence in thinking humanities way out of the mortal danger that individual humans and their environment find themselves in.

“it would seem that the concerns of the Luddite movement are not well founded. From a macroeconomic point of view, it is clear that automation and other related technological advances have fueled over a century of dramatic economic development. There are nonetheless difficult, if often temporary, dislocations that result from rapid technological change...”

“The second industrial revolution, the one that is now in progress, is based on machines that extend, multiply, and leverage our mental abilities. The same controversies on social and economic impact are attending this second great wave of automation, only now a new and more profound question has emerged. Though we have always regarded our species as relatively mediocre in physical capacity, this has not been our view with regard to our mental capacity. The very name we have given ourselves, Homo sapiens, defines us as the thinking people. The primary distinction in our biological classification is the ability of our species to manipulate symbols and use language...”

“This latest revolution, based on machines that expand the reach of our minds, will ultimately have a far greater impact than the revolution that merely expanded the reach of our bodies. It promises to transform production, education, medicine, aids for the handicapped, research, the acquisition and distribution of knowledge, communication, the creation of wealth, the conduct of government, and warfare.”

“A remarkable aspect of this new technology is that it uses almost no natural resources. Silicon chips use infinitesimal amounts of sand and other readily available materials. They use insignificant
amounts of electricity. As computers grow smaller and smaller, the material resources utilized are becoming an inconsequential portion of their value. Indeed, software uses virtually no resources at all. The value of the technology lies primarily in the knowledge governing the design of the hardware, software, and databases that constitute our intelligent machines, and in the ability to continue advancing these designs. (Kurzweil, Age, pp.3-5)”


Pulizer Prize winning author Douglas Hofstradter speaks about representation as a process that is based in imagining patterns and manipulating them. “The crux of creativity resides in the ability to manufacture variations on a theme…Making variations is not just twiddling a knob before you; part of the act is to manufacture the knob yourself. (Hofstadter, p.249)”

Michael Heim, “The Metaphysics of Virtual Reality”

Michael Heim considers the fundamental relationship between the virtual and the real and explores how they interact in the emerging media of simulation. He notices the danger that creates the feeling of reality and the unique (Im)possibilities that create the feeling of virtuality, but that simulation’s value lies in augmenting our experience by modifying the constraints that structure it.

“To banish finite constraints might disqualify virtuality from having any degree of reality whatsoever. Yet to incorporate constraints fully, as some fiction does, is to produce an empty mirror over and above the real world, a mere reflection of the world in which we are anchored…Actual cyberspace should do more; cyberspace should evoke imagination, not repeat the world. Virtual reality could be a place for reflection but the reflection should make philosophy, not redundancy. ’philosophy’, said william james, ‘is the habit of always seeking an alternative.’ Cyberspace can contain many alternate worlds, but the alternateness of an alternate world resides in its capacity to evoke in us alternate thoughts and alternate feelings. (Heim, p.33)”

E.H. Gombrich, *Art and Illusion: A study in the Psychology of Pictorial Representation*

Art Historien Ernst Gombrich inquires into the role that simulation has played in the traditional arts, both from the side of technical illusionism as well as psychological immersion into a work. It is interesting that the technologies of the creator and the viewer used in encoding and decoding a
message are considered in this influential book on the theory of art. Some of the most pertinent passages are quoted at length below.

“And yet Leonardo, if anyone, knew that the artist’s desire to create, to bring forth a second reality, finds its inexorable limits in the restrictions of his medium. I feel we catch an echo of the disillusionment with having created only a picture... when we read in Leonardo’s notes: ‘Painters often fall into despair... when they see that their paintings lack the roundness and the liveliness which we find in objects seen in the mirror... but it is impossible for a painting to look as rounded as a mirror image... except if you look at both with one eye only...’”

“Perhaps the passage betrays the ultimate reason for Leonardo’s deep dissatisfaction with his art, his reluctance to reach the fatal moment of completion: all the artist’s knowledge and imagination are of no avail; it is only a picture that he has been painting, and it will look flat. Small wonder that contemporaries describe him in his later years as most impatient of the brush and engrossed in mathematics. Mathematics was to help him to be the true maker. Today we read of Leonardo’s project to build a ‘flying machine,’ but if we look into Leonardo’s notes we will not find such an expression. What he wants to make is a bird that will fly, and once more there is an exultant tone in the master’s famous prophecy that the bird would fly. (Gombrich, pp. 96-97)”

“What we know of the beginnings of image making confirms the continuous link between finding and making. Recent excavations in Jericho have brought to light a series of images some seven thousand years old that must be the earliest portraits known. They exemplify the Pygmalion sort in reverse. In the latter, a statue came to life, while in these early practices the living man becomes an image after his death. The skull was used as the armature for the modeling. Onto this skull the craftsman spread earth to represent the flesh which had decayed. The head has suffered a sea change into something rich and strange, but it is still the head of the dead. Since eyes, too, decay, the artist had to give the skull artificial eyes, and he found them in the shape of cowrie shells. We know that these shells are used in other contexts as sexual symbols betokening fertility. The difference between symbolization and representation is one of use, of context, of metaphor. In both cases, similarities present a starting point for what I have described somewhat pedantically as the ‘extension of a class.’ Here the class of eyellite objects can take the place of eyes because when they are put in position the skull will suddenly ‘look’ at us. The representation, then is not a replica. It need not be like the motif. The craftsman of Jericho did not think eyes indistinguishable from cowrie shells any more than Picasso thinks baboons indistinguishable from motorcars, but in certain contexts the one can represent the other. They belong to the same class because they release a similar response.

The further back we go in history, the more important this principle appears to be. The test of the image is not its lifelikeness but its efficacy within a context of action. It may be lifelike if theta is thought to contribute to its potency, but in other contexts the merest schema will suffice, provided it retains the efficacious nature of the prototype. It must work as well or better than the real thing...

What matters in the image is that it should preserve and repeat those features of the witch that worked the magic... For if to represent is to create, there must indeed be safeguards against this power
with might easily get out of control... There are stories all over the world of images that had to be chained to prevent their moving of their own accord and of artists who had to refrain from putting the finish tough to their paintings to prevent the images from coming to life. (Gombrich, pp 109-111)"

“The greek revolution may have changed the function and forms of art. It could not change the logic of image making, the simple fact that without a medium and without a schema which can be molded and modified, no artist could imitate reality. We know what the ancients called their schemata; they referred to them as the canon, the basic geometric relationships which the artist must know for the construction of a plausible figure. But the problem of the canon has become overlaid in Greek art by the search for beauty and proportion, and so we may better select a starting point outside the realm of great art to continue our probing of mimesis. We may find such a starting point in a doctoral thesis on the psychology of drawing in which the author, F.C. Ayer, summarizes his conclusions as follows: "The trained drawer acquires a mass of schemata by which he can produce a schema of an animal, a flower, or a house quickly upon paper. This serves as a support for the representation of his memory images and he gradually modifies the schema until it correspond which that which he would express. (Gombrich pp.146-147)"

"How did Constable come to link his admission that there is no art without 'mannerism' (we would say without traditional schemata) with his plea for experimentaation? I think he felt that the history of science presented a story of continuous advance in which the achievements of one observer were used and extended by the next. (Gombrich, p.175)"

**Marshall McLuhan, Understanding Media: The Extensions of Man.**

“The electric light is pure information. It is a medium without a message...the "message" of any medium or technology is the change of scale or pace or pattern that it introduces... (McLuhan, p.10)" More than merely coining catchphrases for techno-utopian evangelism, Marshal McLuhan makes broad, culturally informed predictions about the effect of electronic technology on the way human society will organize itself and relate to its environment.

“Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned. Rapidly, we approach the final phase of the extensions of man-- the technological simulation of consciousness, when the creative process of knowing will be collectively and corporately extended to the whole of human society, much as we have already extended our senses and our nerves by the various media.(McLuhan pp. 5-6)"

McLuhan anticipates the convergence of time and space as well as humans and their
environment through the use of electronic technology. The ethical implications of such a shift in relations would call for careful attention given to how mind and world-altering technology is created and used.

“Western man acquired from the technology of literacy the power to act without reacting... We acquired the art of carrying out the most dangerous social operations with complete detachment. But our detachment was a posture of noninvolvement. In the electric age, when our central nervous system is technologically extended to the whole of mankind and to incorporate the whole of mankind in us, we necessarily participate, in depth, in the consequences of our every action. It is no longer possible to adopt the aloof and dissociated role of the literate Westerner... Electric speed in bringing all social and political functions together in a sudden implosion has heightened human awareness of responsibility to an intense degree. (McLuhan, pp. 6-7)"

**Friedrich Kittler, Optical Media**

Kittler describes the history of visual media in terms of technology independent of humanistic centrism. Technical representation progresses by adding additional dimensions to the interface, beginning with the textual line, into figuration, eventually adding time/movement, until infinite dimensions are achieved with the digital code of visual simulations. This leveling of all representations into the zero-dimentional discrete point of information yields unrestricted manipulation of any and all aspects of simulated worlds.

“Digital image-processing coincides with the real, therefore, precisely because it does not want to be a reproduction like the conventional arts. Silicon chips, which consist of the same element as every pebble on the wayside, calculate and reproduce symbolic structures as digitizations of the real. (Kittler, Optical p.228)"

Words and images are no longer different in digital media, as they are both reducible to quantities that form qualities. Which way humans play with the consequences of the scientific application of logical mathematics, is an ethical question that is completely unrelated to the technology itself.

Seeking to define technology and develop a theory of its process of change, Brian W. Arthur looks at the logical structure of technological innovations and the sub-structures that comprise the tools humans create, while decisively excluding the human aspect of creativity, intention, and desire that give rise to innovation. He describes technology as though it self-generates, although he attempts to maintain a distinction between biological and mechanical forms along the axis of reproduction. He invokes the metaphor of genetic recombination to represent the repurposing of technical components, yet maintains the inherited notion that technology is mechanical and biology is some other unspecified thing, “nothing equivalent to DNA or its cellular workings of course, or as beautifully ordered as this. (Arthur, p.24)” Without acknowledging the implied assumption, that biological forms are considered alive because it reproduces (sexually or asexually, as well as take nutrients from its environment, break down chemicals and synthesize new ones, which it uses to transfer energy so that it can grow, maintain a state of equilibrium, respond to environmental stimuli, and adapt to those conditions), Arthur considers technology similar to chemistry, where a self-contained reaction continuously develops more complex compounds within its environment because of an internal fluctuation of energy that breaks and reforms electrochemical bonds between molecular modules. Lacking an initiating impetus to set off the reaction, Arthur points out the infinite regression of a theory always dependent on an assumed prior state, but maintains a blindness to or silence about what spark might bring the primordial ooze of technology into a state of imbalance. A prior state of imbalance necessitates the lifelike behavior of chemicals and technical logical structures alike to seem to change in response to the redistribution of energy within the environment, adapting the way it anabolizes, metabolizes, grows, and reproduces. Arthur insists on thinking of matter as being either living or dead, biologically self-structuring, or (merely) chemically inert. Despite the assertion of a difference between active and passive material agents within an environment, his concurrent characterization of technology as necessarily mechanical (and therefore instrumental to an intentional consciousness, rational or irrational) and auto-generative: “Technology builds itself organically from itself. (Arthur, p.24)” Arthur’s apparent confusion about what is to be considered alive and/or natural
can be clarified if we dispose of the distinction by tossing it into the semiotic schism from which it emerged and instead look at the environment as a topology woven from the intersections of various intensities, each fluctuating according to a automated program that is regulated by a permeating intelligence. Each sub-structure of technical logic is following a series of biochemical commands, performing transformations within its environment which express the intentionality of the intelligence that created it. The repeated use of such basic commands at various levels of complexity recalls the recursive structure of a fractal, which occurs in the natural environment, yet depends on the manipulation of the square-root of negative one, a so-called imaginary number that is impossible to logically represent other than as a letter that substitutes for the unpresentable reality. Arthur’s model of a dynamically fractalized technical knowledge, being composed of various combinations of reinterpreted logic, is helpful if it is used to bridge the semiotic gap that his description of technical complexity is mired in, until, like all language, or more broadly, like all technology, it happens to notice the absence of a prior state that it is keeping it from plummeting into that very absence; Arthur must conflate semiotic distinctions in order for his model to stand, but in so doing, the intelligence needed for discrete articulation of the model seems to become a form of technology itself, or technology (along with the material environment) a form of intelligence. This continuity between intelligent biological life and dynamically restructuring matter is the reality of our environment that we cannot represent without resorting to the use of stylized approximations we know as technological intelligence. The environment is thoroughly made up of material that expresses a range of signs of intelligence, which can be dismissed as illusory epiphenomena of a mechanistic environment, but the signs of intelligence can be recognized as having a perceivable, yet dynamic structure that intentionally intervenes with the material environment. The sign of intelligence, although only a representation like the imaginary square-root of one, is the cause for the initial and ongoing change in the environment and the virtual body of knowledge that shadows it. Representing technology, itself a method of utilizing representations to effect environmental change, demonstrates the integral role that intelligent simulation plays in re-animating an otherwise static world, assured by the vertigo of floating semiotic structures.
**ii) Fictional Science**

Popular exploration of the brain in a vat scenario. In the sequels, The Matrix Reloaded and The Matrix Revolutions (both from 2003), there is a minor character named Persephone but is not explained.

**Avatar.** Dir. James Cameron. 20th Century Fox, 2009. Film.
Another blockbuster, using telepresence to interface with an endangered indigenous species and help them defend their environment.

**Blade Runner.** Dir. Ridley Scott. Warner Bros, 1982. Film.
Classic application of the Turing Test, a philosophical thought experiment, used to attempt discerning between human and artificial intelligence.

**Silent Running.** Dir. Douglas Trumball. Universal Pictures, 1972. Film.
With the help of some re-programmed drones, a radically nostalgic steward defends scarce botanical life in a space bound biodome.

**Tron.** Dir. Steven Lisberger. Walt Disney Pictures, 1982. Film.
The dream and nightmare of being trapped in a virtual reality.
See above.

Virtual reality gets a mind of its own. But with self-consciousness comes desire, and if self-consciousness isolates itself from its environment, the supporting world is in jeopardy of being sacrificed to delusions of independence.
Computer scientist discovers glitches in a regression of simulated worlds.

Dangerous video game that is so fully immersive that it recursively references the world outside of the game within its sub-game worlds.

Artificial intelligence could preserve the world and fall in love.

iii) Real Science

Optogenetics
An emerging technique in neuroscience involving the stimulation of genetically modified neurons in the brain with light delivered directly through fiber-optic cables, enacting designed cognitive responses in the subject. The ability to use optics in such a way to create new neural pathways that become integrated into the memory of the subject and thus influencing its future behavior and development, is a literal example of how technology bridges the loop between consciousness and its environment, emphasizing the synthetic aspect that results from this condition in nature. Consciousness is a technical simulation of what is always already a component in a larger technical environment. See appendix II for abstracts of several journal articles on the subject.

Heinz von Foerster, “On Constructing a Reality”
“When we perceive our environment, it is we who invent it.” (p.1) Pioneer of cybernetics, Heinz von Foerster illuminates the continuous identity of electronic technology and biological systems. He posits the simulation that consciousness creates is a necessary consequence of the chemical-
electrical bridging of synaptic gaps, creating closure for the organic machine to be able to connect with its environment, and perhaps more importantly, to be able to use cognition recursively to deploy an aesthetically and ethically motivated adjustment to its own behavior and by extension its environment. The feedback loops between consciousness and its environment function recursively, giving rise to new simulated worlds overwriting past simulations.

“The retina of vertebrates with its associated nervous tissue is a typical case of neural computation…it computes any spatial variation in the visual field of this 'eye', independent of intensity of the ambient light and its temporal variations, and independent of place and extension of the obstruction…

Although all operations involved in this computation are elementary, the organization of these operations allows us to appreciate a principle of considerable depth, namely, that of the computation of abstracts…

‘computation’ can be seen on at least two levels, namely, (a) the operations actually performed, and (b) the organization of these operations represented here by the structure of the nerve net…

In computer language (a) would again be associated with “operations”, but (b) with the ‘program’. As we shall see later, in ‘biological computers’ the programs themselves may be computed on. This leads to the concepts of ‘meta-programs’, ‘meta-meta-programs’, . . . etc. This, of course, is the consequence of the inherent recursive organization of those systems…

The nervous system is organized (or organizes itself) so that it computes a stable reality…
This postulate stipulates 'autonomy', i.e., 'self regulation', for every living organism. …It may be strange in times like these to stipulate autonomy, for autonomy implies responsibility.”

iv) Persephone

The first historical mention of Persephone appears in ancient Greek poet Hesiod's Theogony, although it is brief and merely places Persephone within Hades. The more thorough primary source on the mythical origins of Persephone is an anonymous poem of ancient greek origin: the second Homeric Hymn to Demeter (see translated excerpt in appendix).

While Greek myth has been drawn from extensively in cinema and literature, there are no cultural works that have addressed Persephone's story in relation to science (fiction). There are no films focused on Persephone, and the literature that uses her name for a main character tends to embellish the romantic relationship between Persephone and Hades. Nevertheless, it is clear that the Greek world has and continues to inspire our contemporary imaginations.
Some films that do draw from greek mythology include:

**Clash of the Titans. Dir. Louis Leterrier. Warner Bros. 2010.**
Classical mythology: Perseus

**Clash of the Titans. Dir. Desmond Davis. Metro-Goldwyn-Mayer, 1981.**
Classical mythology: Perseus

**Orphée. Dir. Jean Cocteau. DisCina, 1950. Film.**
Classical mythology: Orpheus

**300. Dir. Zach Snyder. Warner Bros., 2007. Film.**
Classical mythology: Sparta

**Hercules. Dir. Ron Clements and John Musker. Walt Disney Pictures, 1997.**
Classical mythology: Hercules

Some of the literature that addresses Persephone specifically includes:

Persephone is the name of a minor character

Persephone and Hades stage kidnapping to elope out of sight of Demeter

**Carter, Aimée. The goddess test. New York: Harlequin Teen, 2011.**
Hades is trying to find a new wife after Persephone didn't work out. Bevis, Kaitlin.

Persephone is saved by hades and grows to love him

\textit{iii) Film/Animation Production}

To evaluate our planned workflow, general filmmaking and animation texts were consulted in order to gauge where our process diverged from the standard model, why we chose to do things differently, and finally to ask which way would be best for this production environment.

For example, in Laybourne’s popular explanation of the animation production process the following breakdown is offered (The Animation Book, pp. 278-290):

\textbf{PreProduction:}

- Conceptualizations
  - Tag
  - Treatment
  - Script
  - Storyboard
- Scheduling
- Budgeting
- Testing

\textbf{Production}

- Animatic
- Layouts
- Animation/Shooting

\textbf{Post-Production}
The most interesting part of this is that the ratio of rendered footage to the final piece is targeted at 1.1:1, whereas a live action project will be closer to the shooting ratio of 20:1. For Axiom, our process was modeled more on the live action standard, where flexibility in available footage allows for greater storytelling options. Comparing examples from Classic filmmakers D.W. Griffeths and Vsevolod Pudovkin, David Guens explains the importance of editing in structuring the ideas in the narrative:

“Whereas Griffith’s tendency is to use close-ups to emotionalize the scene and cutting to contract the entire action back to its figural core or meaningful individual, Pudovkin uses close shots and editing to make us take note of the hard labor involved, stretching it through the entire body of the worker, finally expanding it to other workers and even the world…

“In succession, however, one automatically assumes links of some sort between the images, some immediate connections, a direct filiation. Because the second image is presumed to be relevant to the first on some level, the viewer can be counted on to bring up some interplay between them…

“With the cut, we have literally changed dimensions, we have gone from the seen to the hidden, from merely physical action to intellectual resolution, from one man to a revolutionary cause.” (Guens pp.230-234)

Keeping these approaches in mind, we will review the production process Axiom adopted and discuss its advantages and disadvantages.
Axiom: Production Process

To approach this project and complete it in the time and scope that we needed to, we had to develop a process in which we divided up the work and progressed to the next stage. Our process had to be successful and allow us to progress quickly through our production but also maintain a level of quality control. In doing so we adopted a stage-gate like process which guided us through the beginnings of our idea and ending with the successful launch of our final video. At the beginning we had proposed and decided that we have specific things in which each partner was going to do but as we began progressing through out the process we decided to split the work down the middle and began working together tossing different parts and processes off to each other so that we could continue to get a fresh look at what we were working on so nothing became stale. This work method allowed us to work faster and keep the quality level at a much higher level.

Stage 1: Story Conceptualization

The first stage of our process began after we pitched our ideas during the first thesis presentations.
We both had similar ideas and decided that it would be different and challenging to come up with an thesis that involved an collaborative effort and idea. Our research concluded that we wanted to re-tell the Greek myth of Persephone through a designer’s perspective, as has been discussed earlier in this document.

Stage 2: Modeling

After we developed our story and plot we began to sketch out storyboards in rough detail. After laying them out we adjusted and began to do detailed versions and to re-analyze them. While doing storyboards we also began to develop our character’s identity through rough and detailed sketches along with rough models of her basic form. We also began construction on the room and garden elements in our 3D scene. The room and garden elements were beginning to get modeled during this time because of time constraints. Starting this early on in the process was beneficial because we knew
that we wanted to have diversity in our garden and needed to model a wide number and range of plants in order to establish the look and feel that we were going for.

**Draft 1: Animatic**

After we got to a comfortable point in our story and character development, we produced a rough animatic to give us an idea on the timing of each shot along with their transitions. We shot some scratch video for the introduction sequence and roughly animated our low-polygon 3D models to correspond with the approximated duration for each shot in the storyboard. The animated shots were rendered as cell shaded sequences which, together with the video footage, we could string together into the initial draft of the video. Making the animatic with assets developed in the 3D environment allowed us to see the progression of our story in a visual form closer to the style of the finished piece than the hand-drawn storyboards were. Watching the animatic helped us adjust our estimates about the duration of each shot and the corresponding animation within it, as well as to begin assessing how much time we were going to need to render out the full video.

**Draft 2: Revised Animatic**

We produced a second version of our animatic that retimed the shots and animation. We also included a new batch of scratch video shots to more closely follow the storyboard and test alternate shot composition. In our first animatic we had found that the story had gotten too drawn out and so we had to go back and remove a lot of our scenes in an attempt to focus the visual storytelling on the themes that play a central role in the conflicts of the story, and to do so in such a way that could fit within the time constraints we set for production.

**Stage 3: Texturing**

During this stage of the production process we were still refining our story and scene models. To speed up the process of developing plants and textures for our scene we used Xfrog to generate different types of plants and textures. We modified the stock textures of the plants in order to enhance
and maintain a consistent quality/ look & feel. Finding the appropriate balance between contrasting materials, such as sand, metal, glass, and leaves, for example, to achieve the right mixture of the natural and the synthetic. Adjusting the shaders included experimenting with the appropriate amount of displacement and/or bump mapping to dial in the proper appearance of smoothness versus roughness of the materials, or the amount of transparency or sub-surface scatter depth to dial in the appearance of translucency versus opaqueness. Checking to see how the materials looked in context with one another helped them find stylistic cohesion. Further checking was done by test-rendering frames from the various camera angles the materials appeared in from shot to shot. From an extreme long shot to an extreme close up, a material could change the way it was appeared considerably. Optimization of detail in this fashion as well as with consideration toward target render times rounded off our material selection process. After the texturing of the room and garden was complete we moved forward refining animation shot by shot and beginning to sign off on completed scenes that were ready to move onto lighting and rendering.

Stage 4: Lighting/Rendering

During this time we took separate directions focusing on two major aspects which we needed to get done quickly so that we could begin rendering. This was a crucial in our process because of limited resources we needed to begin rendering right away in order to produce this video on time and at the quality that we wanted it. Work on the main character got put on hold so our focus was on lighting and texturing the room, environment, and garden so we could begin the rendering process, which we expected to require considerable time.

We wanted the lighting of the piece to have a dramatic, hyperrealistic feeling and limited ourselves to physical lights to eliminate the need for global illumination and the longer render times it requires. The solution we found was to isolate the central garden, the main character’s avatar, and the interior space it first appears in. While the main room was lit by volumetric lights built into the floor and server nodes, along with an overhead circular area light, the garden had its own sky dome equipped
with a physical sun emitter as well as a ring of lights parented to the platform, illuminating the underside as it moved upwards in the environment. The main character received its own rig of 8 area lights, each at a corner of an imaginary cage surrounding the character, angled toward the center. The interior space the character first appears in had area lights fit to match the size of the repeating windows along the corridor. Having the lighting setup established, we started to render the completed scenes that excluded our main character.

**Stage 5: Final Animation**

Once we could allot time to completing our main character’s mesh and texture mapping, we developed a list of shots in order of importance and began animating Persephone on a shot by shot basis. To break up the work we broke up the work so that one of us did the rough animation on a few scenes, then the other would go in and refine and make changes where necessary. This allowed us to keep our momentum and keep things fresh by switching up the work and pressing on. When we got to a point where we were comfortable with all the animation we began controlling the render farm rendering out those animated shots.

**Stage 5.5: Video Shoots**

In March, we travelled to Savannah, Georgia to shoot our principle photography using HD video. With Tiffany Cullen acting the part of the scientist, Persephone Greenrose, we shot footage at a beach, a wetland reserve, a graveyard, a botanical garden, and a repurposed old pharmacy. We shot far more than we needed, but gathered as several versions of the opening action in different locations, along with additional B-roll, to allow for flexibility in editing.

**Draft 3: Assembly Cut**

While waiting for the first batches of final renders to calculate, we put together our assembly cut which consisted of the video footage we shot in Savannah and a combination of wireframe renders and some of the fully textured, production quality renders, giving us a taste of how the look was coming together in the stream of the narrative.
Stage 6: Final Rendering

After completing the assembly cut we began getting feedback from our committee; we made the suggested changes relating not only to the editing but also to the animation in some scenes. During this stage we found a lot of areas where we could cut some scenes entirely and shorten others. This helped focus our attention on which of the remaining sequences needed animation to be adjusted. After tweaking the animation, we established a system of setting up each scene for rendering, which included establishing which objects from the scene to make visible, which parameters to enable, which render passes were needed, and setting the frame rate to a number higher than 30, allowing for greater degrees of flexibility for retiming sequences in post-production. Simply keeping track of which shots were complete, which were still unfinished, what the files were named, and where they were stored demanded careful organization and communication from the two of us. Aided by an agreed-upon workflow, we began to upload the files to the farm and to all other available computers.

During this rendering stage we ran into a lot of rendering problems and had to figure out ways to work around the problems or to identify and correct them. Some of the problems that we ran into were that the farm would crash and some of the images would not finish transferring properly so frames were cut in half and causing a lot of weird blinking issues. We solved this problem by rendering out individual frames on our personal machines and swapping them out. We also had problems where Cinema 4D would merge certain channels and give us a messed up multilayer OpenEXR files. We solved that problem re-rendering some stills on personal computers like before but by also using previous frame to fill in the broken area. We also had entire scenes that were messed up with the alpha channel missing from random frames. This unpredicted anomaly was was ultimately corrected by rotoscoping object buffers and using one frame for the background and compositing our main character animation on top. We had to do this for two of our scenes but the solution saved us the time it would have taken to re-render the entire shot. As rendered sequences were completing, we replaced the scratch renders in the assembly cut with the final beauty pass renders and began the next phase of editing by implementing the adjustments after the review of the assembly cut.
Draft 4: Rough Cut

After receiving feedback on the assembly cut and evaluating the cut for ourselves, we knew we had to make some major cuts in our video, reducing the duration of the finished piece. We learned from our evaluation and feedback that there is a big disconnect between the ways people digest narrative information in various forms of media. People will spend hours reading a book to gradually immerse themselves in a story but when they are viewing a video/film, most often they expect it to get to the point quickly and to be entertaining. It was difficult for both of us to wrap our head around this concept because of our love for long stories and movies. Our assembly cut reflected this taste for a more deliberate, event-oriented pace to editing a film but as we removed excess time, our cuts began to flow better, to grab users’ attention, and to maintain that grasp more universally. Viewers also began to understand the story more because the details were clearer and more to the point.

This first pass at refining the edit, the first ‘rough cut’, brought the duration of the video down to eight minutes (down from the eleven minute assembly cut we had shown previously). We focused on tightening the sequences by cutting closer to the essential actions in each shot and removing lead up and out action. The new edit moved at a faster pace, which had better continuity, however the balance of the still seemed off, with half of the screen time devoted to the introductory video scenes. Supported by corroborating feedback from our advisors, we decided to make another revision of the edits.

Draft 5: Fine Cut

The second rough cut required more structural decisions to be made in order to achieve a more appropriate balance between the durations of the beginning, middle, and end. Several scenes of the scientist sampling different plants in the live-action introduction proved unnecessary for establishing the identity of the protagonist and the situation she was involved in. Also, removing the transition scene where the scientist moves into the virtual space helped maintain momentum and connectivity between the live-action and 3D sections of the video; substituting and flickering enlargement of the last live-action close-up shot before cutting directly into the 3D world ended
up being more conducive to viewer immersion. The middle, 3D portion of the video needed to be the longest and needed a stronger establishment of the environment, what would be considered the antagonist in the story; we gave more time to the close-up of the glowing server nodes at the perimeter surrounding the garden where most of the action takes place. Because we rendered the animation at a frame rate higher than 30, we were able to slow down and speed up the animation in certain areas to create more dynamic moments and to smooth out some glitches that appeared in the rendered motion. The end of the video was getting stretched out by too many phases to its resolution. The weak link in the sequence after the virtual environment experiences the fatal error was the long shot of the environment imploding, which we removed after deciding it was specially disorienting, stylistically mismatched, and narratively disruptive. We also changed ending by using a closer shot as the background for the integration of the virtual flower to the live-action environment. The closer shot omitted the scientist from the composition, leaving her physical fate open to interpretation. Rather than forcing an interpretation on the audience about what the effects of experimental genetic manipulation and consciousness-intervening simulation would be. Once the fine-tuning of the narrative balance was at a point we were comfortable with, we decided to move forward to the finishing stages of post production.

Stage 7: Finishing & Audio
With a fine cut trimmed, finishing post production commenced. We created a color grading style template in After Effects and did a still of every scene so that we could make sure the transitions of the styles were consistent and were visually appealing. Special attention was given to finding the right relationship between the live action and CG looks, in terms of color balance and value curves. We also added the user interfaces in post production using motion tracking for the interfaces along with other effects such as the lights on our character.

We realized how much backstory was left out of the visual presentation, and decided it could be supplemented with a few lines of introductory voice over, as well as accenting the scenes where the computer system is communicating. We quickly wrote some lines and sent them to our actress,
Tiffany Cullen, who had a recording engineer friend send audio files of her reading.

We had plans to compose the musical bed for the video but because of our tight schedule we obtained permission to use 4 unreleased tracks by the electronic musician Access to Arasaka, which we selected for its juxtaposition of ethereal, atmospheric soundscapes with glitchy, distorted, synthetic percussion patterns, recalling the mood of cyberpunk fiction. Focusing on editing audio assets to match the tone and pacing of the narrative made us able to get close to what we wanted within a short period of time which gave us more time to spend on compositing.

**Final Video**

Our final video was completed in time for our show which was a success and also a surprise to a lot of people who doubted our idea for completion time. We showed our video in progressive 3D which added a lot of depth to our film. Putting the Pixar process next to ours our processes were practically the same except for the amount of time that the Pixar team spend critiquing and getting the okay for every model, environment, animation and scene. They are able to spend that amount of time and attention to achieve that level of quality because of the workforce and funding behind them. Because we lacked everything from time to money we had to cut corners and spend more time working and pushing out scenes rather than spending so much time on scrutinizing one thing. Doing this allowed us to move faster and get it down within the short period of time that we had to get this project finished.
Evaluation

i) General Feedback
From our advisors and peers in school, the general feedback was positive in terms of overall look and feel, although there were some concerns with the naturalism of the animation and compositing in a couple scenes.

ii) Questionnaire
In order to gauge the target audience's reaction to the piece, we selected a group generally representative of young adults interested in cinema or science-fiction. Questions were aimed to measure the degree to which the viewer followed the plot of the story with additional space given to freeform responses. The audience had no specific knowledge of AXIOM prior to viewing, and only one viewing was permitted, with responses given immediately afterwards.

The questionnaire used can be found in Appendix III.

Of the 5 questions in the questionnaire, the breakdown of the responses are as follows:

<table>
<thead>
<tr>
<th>Results:</th>
<th>%CORRECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 A B C 18+1 D E 1 NOANSWER</td>
<td>100%</td>
</tr>
<tr>
<td>Q2 A 2 B 9+3 C 1+1 D E 5 NOANSWER 2</td>
<td>63%</td>
</tr>
<tr>
<td>Q3 A 5 B 1 C D 11-1+1 E 2 NOANSWER 1</td>
<td>57%</td>
</tr>
<tr>
<td>Q4 A 9 B C 7 D E 1 NOANSWER 2</td>
<td>47%</td>
</tr>
<tr>
<td>Q5 A B C 14-1 D E 5 NOANSWER 1</td>
<td>74%</td>
</tr>
</tbody>
</table>

(intended responses Q1 C Q2 B Q3 D Q4 A Q5 C)
Certain interpretation was required in the case of the ‘other’ responses where the answer corresponds with a given answer a +1 is added to the tally, but where the other answer admits uncertainty about the answer given a -1 is added.

As can be seen there is strength in the setup of the story, but its development seems to lose approximately half the audience.

**The general responses offered from the pooled viewers:**

“The story was a bit confusing too me.

But I really liked the flower...”

“I appreciate the exposition of the scientist at the beginning, which reminds me of a television program, which is contrasts with the virtual environment and its very sterile, ‘auto pilot’ sensibility...”

“I fully enjoyed the aesthetics. I enjoyed the concept. I really liked the music. The musical piece was mixed a little loud and distracted from the narrative...”

“My interpretation of AXIOM was a close relation to rebirth and regeneration. I felt like I was in the future looking back at an old archive of a prior generation. Locating a pure specimen that is no longer in existence. The system could not recognize the seed and threw up an error msg. After overriding it the scientist began to regenerate the flower. I hope the piece is planted into the current time and resurrected back onto earth (or whatever planet). Kinda like some Jurrasic Park shit but way cooler. I assume earth because of the english accent. I love Access to Arasaka ( i fuckin’ called it bro). The 3D effects were amazing. Total TITS! Ps: I smelled rob all over that shit :) But honestly I loved the lights coming across the screen as the transporter passed by. I thought the colors were great. I would play around with the different tints and filters a bit in the beginning reality scene. I liked the drawers in the beginning, saw some body parts written on there i think aha. I liked that the scientist second guessed her plan. the scenario is realistic but i felt no emotion from her it was cold and absent. unless that is what you were going for i thought she could have played it differently. I could respect the muted imagery to tell a story though, if that makes sense. I would use something diff than an iPad. They will have something way cooler by that point. All and all an awesome video and i’m stoked to see more to come. The ending isn't clear if the new specimen is real or holographic. It would be desirable for the specimen would be real. It seems like she is in an archive! I believe the scientist is just fine and she will get out okay. maybe She is just burning the midnight oil when the rest of the ream is asleep because the program is getting its funding cut but she is elbow deep in this research and wants it to move foreword.”
“Would like to watch again, however the presentation was in such a way that i was unable to give additional feedback and observe my own feedback .”

“The effects on the PDA device were great, and the video really grips you from beginning to end. I did feel like there may have been certain sounds lacking during the end when the seed drops and the archive view flies around .”

“It moves fast and i there is so much going on visually and with the sound that the plot gets a little lost on me. but I’m not totally lost at all and i kind of enjoy the fact that its difficult to grasp. the visuals tell a lot of the story and the consistency of the space does a lot to hold the story together .”

“Did she return? or was her mind fully entranced in the system?”

“Establish the world/story a bit more clearly in the beginning, if you want slower/more passive viewers to get all the information. I was really engrossed n the wonderful and sound and lost track of the story. So, depending on how important the storyline is (over general mood) consider establishing the world more strongly in the beginning .”

“Not sure what was done with the information, but she seemed to find something that could help her...? ”

“I had difficulties picking up the specific bits of information - names, etc. - asked about in these questions. I’m not sure how important they are. I have a hard time believing that the machines and seeds and genomes were present within a data space - it seemed moreso that she was operating some mechanism (perhaps some nano-bots or whatever) in a separate space within reality. perhaps a virtual representation of the data analysis processes that were going on, but it all seemed real-ish to me. This could have been a dream, but it was too logical to be a dream in terms of narrative flow. Definitely dreamy. But not a dream. Perhaps interfacing with the computer in that way induced a hallucination that was a representation of the data/genome space, which allowed here to manipulate things in a real way. It’s unclear, but not in a bad way. It requires some imagination work to put together the pieces.”

“Voice of computer was difficult to understand at points. Plants and the white drone were done especially well .”
“I’m sure if I watched it again I would understand it more fully. It’s very dense in both the language and visually so it’s a lot to take in on first viewing. Very cool.”

“The giant flower near the end looks like fireworks, evoking the power and wonder they bring. Overall, I think this is a great piece. I have not seen much animation before from Pete and this is very impressive. I remember projects we worked on many years ago trying all sorts of styles. It’s wonderful to see how far he has come with his craft. The ease of versatility is impressive.”

“Very engaging, enjoyed a lot. profusely. liked the way the song went and helped tell the story of the seed...”

“I was put off by this questionnaire. as if quantitative data can encapsulate my experience viewing this film. i understand that this “quiz” is meant to determine whether or not i followed the plot or overarching meaning of the film, but to me, there are so many other components to my experience that this quiz never addresses. for instance, the music and the choice of visual effects greatly influenced my experience of the film, and in general, my interpretation of its meaning. these components are not addressed by the questionnaire. the film is very short for the complexity of its meaning. i would not be surprised if many people miss aspects of its plot initially. however, the true question should be what they did receive, and that may not be answerable in the limited format of a survey focused entirely on plot. i thought the whole film was funny, disturbing and strange, and left me with a mixture of uncertainty and hope that was not all together unpleasant.”

“Beautiful!”
**iii) Interpretative Evaluation**

The concept of the story was relevant and interesting to the target audience, however, the pace and style were perhaps too dense to explore the ideas in a digestible way within a single five minute viewing. Axiom, due to its layers of complexity built into the film, is accessible to its audience on a visual level, with added narrative and conceptual resolution to those who process information at a higher rate and are querying the film with their own interpretive processes. The audience inevitably reconstructs a film with their own biased sampling algorithm.

**Conclusions**

We proposed to use a designer’s approach to style and project ideation to construct a narrative video with 3D and 2D computer generated elements to reflect on the position that technology plays within the human-populated environment and on the responsibility the makers and users of technology have in shaping the environment of the immanent future. The video was meant to work by example in using technology to create a stylized representation of the possible near-future to entice audiences to consider the direction of technological development in our society. We succeeded in executing the project within the proposed schedule, and based on our feedback, succeeded in creating an attractive piece, although certain aspects of the story were lost on some viewers. Overall, however, Axiom succeeds in creating a world that audiences can relate to, based on our current point in the trajectory of technological development and its relationship with the biological environment. What specific cognitive realities are created from use of this technological artifact remains unknown.
I begin to sing of Demeter, the holy goddess with the beautiful hair.
And her daughter [Persephone] too. The one with the delicate ankles, whom Hadês[1] seized. She was given away by Zeus, the loud-thunderer, the one who sees far and wide.
Demeter did not take part in this, she of the golden double-axe, she who glories in the harvest.

She [Persephone] was having a good time, along with the daughters of
Okeanos, who wear their girdles slung low.
She was picking flowers: roses, crocus, and beautiful violets.
Up and down the soft meadow. Iris blossoms too she picked, and hyacinth.
And the narcissus, which was grown as a lure for the flower-faced girl
by Gaia [Earth]. All according to the plans of Zeus. She [Gaia] was doing a favor or the one
who receives many guests [Hadês].

It [the narcissus] was a wondrous thing in its splendor. To look at it gives a sense of holy awe
to the immortal gods as well as mortal humans.
It has a hundred heads growing from the root up.
Its sweet fragrance spread over the wide skies up above.
And the earth below smiled back in all its radiance. So too the churning mass of the salty sea.

She [Persephone] was filled with a sense of wonder, and she reached out with both hands
to take hold of the pretty plaything.[2] And the earth, full of roads leading every which way, opened up under her.

It happened on the Plain of Nysa. There it was that the Lord who receives many guests made his lunge.

He was riding on a chariot drawn by immortal horses. The son of Kronos. The one known by many names.

He seized her against her will, put her on his golden chariot,

20 And drove away as she wept. She cried with a piercing voice,

calling upon her father [Zeus], the son of Kronos, the highest and the best.

But not one of the immortal ones, or of human mortals, heard her voice. Not even the olive trees which bear their splendid harvest.
Except for the daughter of Persaios, the one who keeps in mind the vigor of nature.

25 She heard it from her cave. She is Hekatê, with the splendid headband. And the Lord Helios [Sun] heard it too, the magnificent son of Hyperion.
They heard the daughter calling upon her father, the son of Kronos.
But he, all by himself, was seated far apart from the gods, inside a temple, the precinct of many prayers.
He was receiving beautiful sacrificial rites from mortal humans.

30 She was being taken, against her will, at the behest of Zeus,
by her father's brother, the one who makes many sêmata, the one who receives many guests, the son of Kronos, the one with many names. On the chariot drawn by immortal horses.
So long as the earth and the star-filled sky were still within the goddess's [Persephone's] view, as also the fish-swarming sea [pontos], with its strong currents,
as also the rays of the sun, she still had hope that she would yet see her dear mother and that special group, the immortal gods.

For that long a time her great noos was soothed by hope, distressed as she was. The peaks of mountains resounded, as did the depths of the sea [pontos], with her immortal voice. And the Lady Mother [Demeter] heard her.

And a sharp akhos seized her heart. The headband on her hair she tore off with her own immortal hands and threw a dark cloak over her shoulders. She sped off like a bird, soaring over land and sea, looking and looking. But no one was willing to tell her the truth [etêtuma],

not one of the gods, not one of the mortal humans, not one of the birds, messengers of the truth [etêtuma].

Thereafter, for nine days did the Lady Demeter wander all over the earth, holding torches ablaze in her hands. Not once did she take of ambrosia and nectar, sweet to drink,

in her grief, nor did she bathe her skin in water.

But when the tenth bright dawn came upon her, Hekatê came to her, holding a light ablaze in her hands. She came with a message, and she spoke up, saying to her:

“Lady Demeter, bringer of hôrai, giver of splendid gifts,

which one of the gods who dwell in the sky or which one of mortal humans seized Persephone and brought grief to your philos thûmos?

I heard the sounds, but I did not see with my eyes
who it was. So I quickly came to tell you everything, without error.”
So spoke Hekatê. But she was not answered

by the daughter [Demeter] of Rhea with the beautiful hair. Instead, she
[Demeter] joined her [Hekatê] and quickly
set out with her, holding torches ablaze in her hands.
They came to Hêlios, the seeing-eye of gods and men.
They stood in front of his chariot-team, and the resplendent goddess asked this question:
“Helios! Show me respect [aidôs], god to goddess, if ever

I have pleased your heart and thûmos in word or deed.
It is about the girl born to me, a sweet young seedling, renowned for her beauty,
whose piercing cry I heard resounding through the boundless aether,
as if she were being forced, though I did not see it with my eyes.
I turn to you as one who ranges over all the earth and sea [pontos]
as you look down from the bright aether with your sunbeams:
tell me without error whether you have by any chance seen my philon child,
and who has taken her away from me by force, against her will,
and then gone away? Tell me which one of the gods or mortal humans did it.”
So she spoke. And the son of Hyperion answered her with these words:

“Daughter of Rhea with the beautiful hair, Queen Demeter!
You shall know the answer, for I greatly respect you and feel sorry for you
as you grieve over your child, the one with the delicate ankles. No one else
among all the immortals is responsible [aitios] except the cloud-gatherer Zeus himself,
who gave her to Hadês as his beautiful wife. So he gave her to his own brother. And he
[Hadês], heading for the misty realms of darkness,
seized her as he drove his chariot and as she screamed out loud.

But I urge you, goddess: stop your loud cry of lamentation: you should not have an anger without bounds, all in vain. It is not unseemly to have, of all the immortals, such a son-in-law as Hadês, the one who makes many sêmata.

He is the brother [of Zeus], whose seed is from the same place. And as for tîmê, he has his share, going back to the very beginning, when the three-way division of inheritance was made.[3]

He dwells with those whose king he was destined by lot to be.”[4]

So saying, he shouted to his horses, and they responded to his command as they swiftly drew the speeding chariot, like long-winged birds.

And she [Demeter] was visited by grief [akhos] that was even more terrible than before: it makes you think of the Hound of Hadês.

In her anger at the one who is known for his dark clouds, the son of Kronos, she shunned the company of gods and lofty Olympus.

She went away, visiting the cities of humans, with all their fertile landholdings, shading over her appearance, for a long time. And not one of men,

looking at her, could recognize her. Not one of women, either, who are accustomed to wear their girdles low-slung.[5]

Until, one day, she came to the house of bright-minded Keleos, who was at that time ruler of Eleusis, fragrant with incense.[6]

She sat down near the road, sad in her philon heart, at the well called Parthenion [the Virgin's Place], where the people of the polis[7] used to draw water.
She sat in the shade, under the thick growth of an olive tree, looking like an old woman who had lived through many years and who is deprived of giving childbirth and of the gifts of Aphrodite, lover of garlands in the hair. She was like those nursemaids who belong to kings, administrators of themistes, and who are guardians of children in echoing palaces.

She was seen by the daughters of Keleos, son of Eleusinos, who were coming to get water, easy to draw [from the well], in order to carry it in bronze water-jars to the phila home of their father. There were four of them, looking like goddesses with their bloom of adolescence: Kallidikê, Kleisidikê, and lovely Dêmô.

And then there was Kallithoê, who was the eldest of them all. They did not recognize her [Demeter]. Gods are hard for mortals to see. They [the daughters] stood near her and spoke these winged words: “Who are you, and where are you from, old woman, old among old humans? Why has your path taken you far away from the polis? Why have you not drawn near to the palace?

There, throughout the shaded chambers, are women who are as old as you are, and younger ones too, who would welcome you in word and in deed.”

So she spoke.[8] And the Lady Goddess spoke with the following words: “Phila children! Whoever women you are among the female kind of humans, I wish you kharis [‘I wish you pleasure and happiness from our relationship, starting now’]. I shall tell you. It is not unseemly,
since you ask, for me to tell you alêtea.

Dôsô[9] is my name. It was given to me by my honored mother.

But that was then. I am from Crete, having traveled over the wide stretches of sea against my will. Without my consent, by bià, by duress,

125 I was abducted by pirates. After a while, sailing with their swift ship, they landed at the harbor of Thorikos. There the ship was boarded by women of the mainland, many of them. They [the pirates] started preparing dinner next to the prow of the beached ship.

But my thûmos did not yearn for food, that delight of the mind.

130 I stole away and set out to travel over the dark earth of the mainland, fleeing my arrogant captors. This way, I stopped them from drawing any benefit from my worth without having paid the price.

That is how I got here, in the course of all my wanderings. And I do not know what this land is and who live here.

135 But I pray to all the gods who abide on Olympus that you be granted vigorous husbands and that you be able to bear children, in accordance with the wishes of your parents. As for me, young girls, take pity.

To be honest about it, what I want is for you to name for me a house to go to, the house of someone, man or woman, who has phila children to be taken care of.[10]

I want to work for them,

140 honestly. The kind of work that is cut out for a female who has outlived others her own age. I could take some newborn baby in my arms, and nourish him well. I could watch over his house.
I would make his bed in the inner recesses of well-built chambers, 
the royal bed. And I could see to a woman’s tasks.”

145 So spoke the goddess. And she was answered straightaway by the unwed maiden, 
Kallidikê, the most beautiful of the daughters of Keleos:

“All Mother, we humans endure the gifts the gods give us, even when we are grieving over 
what has to be.[11] 
They [the gods] are, after all, far better than we are. 
What I now say will be clear advice, and I will name for you

150 the men who have the great control, divinely given, of tîmê here: 
the men who stand at the forefront of the dêmos and who protect the citadel of the polis 
with their wise counsel and their straight dikai. 
And then there are the wives too: of sound-minded Triptolemos, of Dioklos, 
of Polyxenos, of faultless Eumolpos as well, 

155 of Dolikhos, and of our splendid father [Keleos]. 
The wives of all of these manage the palace.[12] 
Of these women, not a single one of them, when they first look at you, 
would deprive you of tîmê, the way you look, and turn you away from the palace. 
Rather, they will receive you. For, right now, you look like the gods.

160 If you wish, wait for us, while we go to the palace of our father 
and tell our mother, Metaneira with the low-slung girdle, 
all these things from beginning to end, in the hope that she will tell you 
to come to our house and not to seek out the houses of others.[13] 
She has a treasured son, growing up in the well-built palace.
He was born late, after many a prayer for the birth of a son: a great joy to his parents.
If you nourish him to grow till he reaches the crossing-point of life, coming of age,
I can predict that you will be the envy of any woman who lays eyes on you.
That is how much compensation she [Metaneira] would give you in return for raising him.”
So she [Kallidikê] spoke. And she [Demeter] nodded her assent. So they,

filling their splendid jars with water, carried it off, looking magnificent.
Swiftly they came to the great palace of their father, and quickly they told their mother
what they saw and heard.[14] And she told them
quickly to go and invite her [Demeter] for whatever wages, no limits,
and they, much as deer or heifers in the hôrâ of spring

prance along the meadow, satiating their dispositions as they graze on the grass,
so also they, hitching up the folds of their lovely dresses,
dashed along the rutted roadway, their hair flowing
over their shoulders, looking like crocus blossoms.
They found the illustrious goddess sitting near the road, just the way

they had left her. Then they led her to the phila palace of their father.
She was walking behind them, sad in her philon heart.
She was wearing a veil on her head, and a long dark robe [peplos]
trailed around the delicate feet of the goddess.[15]
Straightaway they came to the palace of sky-nurtured[16] Keleos.

They went through the hall, heading for the place where their mistress, their mother,
was sitting near the threshold of a well-built chamber,
holding in her lap her son, a young seedling. And they ran over
to her side. She [Demeter] in the meantime went over to the threshold and stood on it, with feet firmly planted, and her head reached all the way to the ceiling. And she filled the whole indoors with a divine light.

She [Metaneira] was seized by a sense of aidôs, by a holy wonder, by a blanching fear. She [Metaneira] yielded to her [Demeter] the chair on which she was sitting, and she told her to sit down.

But Demeter, the bringer of hôrai, the giver of splendid gifts, refused to sit down on the splendid chair, but she stood there silent, with her beautiful eyes downcast,

until Iambê, the one who knows what is worth caring about [kednon] and what is not, set down for her a well-built stool, on top of which she threw a splendid fleece.[17]

On this she [Demeter] sat down, holding with her hands a veil before her face. For a long time she sat on the stool, without uttering a sound, in her sadness. And she made no approach, either by word or by gesture, to anyone.

Unsmiling, not partaking of food or drink, she sat there, wasting away with yearning for her daughter with the low-slung girdle, until Iambê,[18] the one who knows what is dear and what is not, started making fun. Making many jokes, she turned the Holy Lady’s disposition in another direction, making her smile and laugh and have a merry thûmos. Ever since, she [Iambê] has been pleasing her [Demeter] with the sacred rites.

Then Metaneira offered her [Demeter] a cup, having filled it with honey-sweet wine. But she refused, saying that it was divinely ordained that she not drink red wine. Then she [Demeter] ordered her [Metaneira] to mix some barley and water
with delicate pennyroyal, and to give her [Demeter] that potion to drink.

So she [Metaneira] made the kukeôn[19] and offered it to the goddess, just as she had ordered. The Lady known far and wide as Dêô[20] accepted it, for the sake of the hosia.[21] Then well-girded Metaneira spoke up in their midst:

“Woman, I wish you kharis [‘I wish you pleasure and happiness from our relationship, starting now’]. I speak this way because I think you are descended not from base parents but from noble ones. You have the look of aidôs in your eyes,

and the look of kharis, just as if you were descended from kings, who uphold the themistês. We humans endure the gifts the gods give us, even when we are grieving over what has to be. The yoke has been placed on our neck. But now that you have come here, there will be as many things that they give to you as they give to me. Take this little boy of mine and nourish him. He is late-born, and it was beyond my expectations that the immortals could have given him to me. I prayed many times to have him. If you nourish him to grow till he reaches the crossing-point of life, coming of age, I can predict that you will be the envy of any woman who lays eyes on you. That is how much compensation I [Metaneira] would give you in return for raising him.”

Then Demeter, with the beautiful garlands in her hair, addressed her:

“Woman, I wish you kharis back, and then some. May the gods give you good things. With positive intentions, I will take your little boy as you tell me to. I will nourish him, and I do not expect that, through the inadverrence of her nursemaid,
he would perish from a pestilence or from the Undercutter.[22]
I know an antidote[23] that is far more powerful than the Woodcutter;[24]

I know a genuine remedy for the painful pestilence.”

Having so spoken, she took the child to her fragrant bosom,
in her immortal hands. And the mother [Metaneira] rejoiced in her mind.
And thus it came to pass that the splendid son of bright-minded Keleos,
Dêmophôn,[25] who was born to well-girded Metaneira,

was nourished in the palace, and he grew up like a daimôn,
not eating grain, not sucking from the breast. But Demeter
used to anoint him with ambrosia, as if he had been born of the goddess,
and she would breathe down her sweet breath on him as she held him to her bosom.
At nights she would conceal him within the menos of fire, as if he were a smoldering log,

and his philoi parents were kept unaware. But they marveled
at how full in bloom he came to be, and to look at him was like looking at the gods.[26]
Now Demeter would have made him ageless and immortal
if it had not been for the heedlessness of well-girded Metaneira,
who went spying one night, leaving her own fragrant bedchamber,

and caught sight of it [what Demeter was doing]. She let out a shriek and struck her two
thighs,[27]
afraid for her child. She had made a big mistake in her thûmos.
Weeping, she spoke these winged words:
“My child! Demophon! The stranger, this woman, is making you disappear in a mass of flames!
This is making me weep in lamentation [goos]. This is giving me baneful anguish!”
So she spoke, weeping. And the resplendent goddess heard her.

Demeter, she of the beautiful garlands in the hair, became angry at her

[Metaneira].

She [Demeter] took her [Metaneira’s] philos little boy, who had been born to her

mother in the palace, beyond her expectations,

—she took him in her immortal hands and put him down on the floor, away from her.[28] 

She had taken him out of the fire, very angry in her thûmos,

and straightaway she spoke to well-girded Metaneira:

“Ignorant humans! Heedless, unable to recognize in advance

the difference between future good fortune [aisa] and future bad.

In your heedlessness, you have made a big mistake, a mistake without remedy.

I swear by the Styx,[29] the witness of oaths that gods make, as I say this:

immortal and ageless for all days

would I have made your philos little boy, and I would have given him tîmê that is

unwilting [a-phthi-tos].[30]

But now there is no way for him to avoid death and doom.[31]

Still, he will have a tîmê that is unwilting [a-phthi-tos], for all time, because he had once sat

on my knees and slept in my arms.

At the right hôrâ, every year,

the sons of the Eleusinians will have a war, a terrible battle

among each other. They will do so for all days to come.[32]

I am Demeter, the holder of tîmai. I am the greatest

boon and joy for immortals and mortals alike.
270 But come! Let a great temple, with a great altar at its base,
be built by the entire dêmos. Make it at the foot of the acropolis and its steep
walls.
Make it loom over the well of Kallikhoron,[33] on a prominent hill.
And I will myself instruct you in the sacred rites so that, in the future,
you may perform the rituals in the proper way and thus be pleasing to my noos.”

275 So saying, the goddess changed her size[34] and appearance,
shedding her old age, and she was totally enveloped in beauty.
And a lovely fragrance wafted from her perfumed robes.
The radiance of her immortal complexion
shone forth from the goddess. Her blond hair streamed down her shoulder.

280 The well-built palace was filled with light, as if from a flash of lightning.
She went out of the palace, and straightaway her [Metaneira’s] knees buckled.
For a long time she [Metaneira] was speechless. She did not even think of
her treasured little boy, to pick him up from the floor.
But his sisters heard his plaintive wailing,

285 and they quickly ran downstairs from their well-cushioned bedrooms. One of them
picked up the child in her arms, clasping him to her bosom.
Another one rekindled the fire. Still another one rushed, with her delicate feet,
to prop up her mother as she was staggering out of the fragrant room.
They all bunched around the little boy, washing him as he gasped and spluttered.

290 They all kept hugging him, but his thûmos could not be comforted.
He was now being held by nursemaids who were far inferior.
All night they prayed to the illustrious goddess,
trembling with fear. And when the bright dawn came,
they told Keleos, who rules far and wide, exactly what happened,

295 and what the goddess Demeter, the one with the beautiful garlands in the hair, instructed them to do.
Then he [Keleos] assembled the masses of the people, from this end of the public place to the other,
and he gave out the order to build, for Demeter with the beautiful hair, a splendid temple,
and an altar too, on top of the prominent hill.
And they obeyed straightaway, hearing his voice.

300 They built it as he ordered. And the temple grew bigger and bigger, taking shape through the dispensation of the daimôn.[35]
When the people had finished their work and paused from their labor,
they all went home. But blond-haired Demeter
sat down and stayed there [in the temple], shunning the company of all the blessed ones [the gods].
She was wasting away with yearning for her daughter with the low-slung girdle.

305 She made that year the most terrible one for mortals, all over the Earth, the nurturer of many.
It was so terrible, it makes you think of the Hound of Hadês. The Earth did not send up
any seed. Demeter, she with the beautiful garlands in her hair, kept them [the seeds] covered underground..
Many a curved plough was dragged along the fields by many an ox—all in vain.
Many a bright grain of wheat fell into the earth—all for naught.
At this moment, she [Demeter] could have destroyed the entire race of meropes[36] humans with harsh hunger, thus depriving of their tíμê the dwellers of the Olympian abodes—[the tíμê of] sacrificial portions of meat for eating or for burning,[37] if Zeus had not noticed with his noos, taking note in his thûmos.

First, he sent Iris, with the golden wings, to summon

Demeter with the splendid hair, with a beauty that is much loved.

That is what he told her to do. And she obeyed Zeus, the one with the dark clouds, the son of Kronos, and she ran the space between sky and earth quickly with her feet.[38] She arrived at the city of Eleusis, fragrant with incense, and she found in the temple Demeter, the one with the dark robe.

Addressing her, she spoke winged words:

“Demeter! Zeus, the one who has unwilting [a-phthi-ta] knowledge, summons you to come to that special group, the company of the immortal gods. So then, come! May what my words say, which come from Zeus, not fail to be turned into action that is completed.”

So she spoke, making an entreaty. But her [Demeter’s] thûmos was not persuaded.

After that, the Father sent out all the other blessed and immortal gods. They came one by one, they kept calling out to her, offering many beautiful gifts,
all sorts of tîmai that she could choose for herself if she joined the company of the immortal
gods.

But no one could persuade her in her thinking or in her intention [noêma],

330 angry as she was in her thûmos, and she harshly said no to their words.
She said that she would never go to fragrant Olympus,
that she would never send up the harvest of the earth,
until she saw with her own eyes her daughter, the one with the beautiful looks.
But when the loud-thunderer, the one who sees far and wide, heard this,

335 he sent to Erebos [Hadês] the one with the golden wand, the Argos-killer

[Hermes],[39]
so that he may persuade Hadês, with gentle words,
that he allow holy Persephone to leave the misty realms of darkness
and be brought up to the light in order to join the daimones [the gods in
Olympus], so that her mother may
see her with her own eyes and then let go of her anger.

340 Hermes did not disobey, but straightaway he headed down beneath the depths of the earth,
rushing full speed, leaving behind the abode of Olympus.
And he found the Lord inside his palace,
seated on a funeral couch, along with his duly acquired bedmate,
the one who was much under duress, yearning for her mother, and suffering
from the unbearable things

345 inflicted on her by the will of the blessed ones.[40]

Going near him [Hadês] and stopping, the powerful Argos-killer said to him:
“Hadês! Dark-haired one! King of the dead!
Zeus the Father orders that I have splendid Persephone
brought back up to light from Erebos back to him and his company, so that her
mother
350 may see her with her own eyes and let go of her wrath and terrible mênis
against the immortals. For she [Demeter] is performing a mighty deed,
to destroy [root phthi-] the tribes of earth-born humans, causing them to be
without menos,
by hiding the Seed underground—and she is destroying [root phthi-] the timai
of the immortal gods.[41] She has a terrible anger, and she refuses
to keep company with the gods. Instead, far removed, she is seated inside
a temple fragrant with incense. She has taken charge of the rocky citadel of Eleusis.”
So he spoke. Hadês, King of the Dead, smiled
with his brows,[42] and he did not disobey the order of Zeus the King.
Swiftly he gave an order to bright-minded Persephone.

360 “Go, Persephone, to your mother, the one with the dark robe.
Have a kindly disposition and thûmos in your breast.
Do not be too upset, excessively so.
I will not be an unseemly husband to you, in the company of the immortals.
I am the brother of Zeus the Father. If you are here,

365 you will be queen of everything that lives and moves about,
and you will have the greatest timai in the company of the immortals.
Those who violate dikê– will get punishment for all days to come
—those who do not supplicate your menos with sacrifice,
performing the rituals in a reverent way, executing perfectly the offerings that are due.”
370 So he spoke. And high-minded Persephone rejoiced.

Swiftly she set out, with joy. But he [Hadês]
gave her, stealthily, the honey-sweet berry of the pomegranate to eat,
peering around him.[43] He did not want her to stay for all time
over there, at the side of her honorable mother, the one with the dark robe.

375 The immortal horses were harnessed to the golden chariot
by Hadês, the one who makes many sêmata.
She got up on the chariot, and next to her was the powerful Argos-killer,
who took reins and whip into his philai hands
and shot out of the palace [of Hadês]. And the horses sped away eagerly.

380 Swiftly they made their way along the long journey. Neither the sea
nor the water of the rivers nor the grassy valleys
nor the mountain peaks could hold up the onrush of the immortal horses.
High over the peaks they went, slicing through the vast air.
He came to a halt at the place where Demeter, with the beautiful garlands in the hair,

385 was staying, at the forefront of the temple fragrant with incense. When she [Demeter] saw
them, she rushed forth like a maenad[44] down a wooded mountainslope.

387-400[45]

401 But when the earth starts blossoming with fragrant flowers of springtime,
flowers of every sort, then it is that you must come up from the misty realms of darkness,
once again, a great thing of wonder to gods and mortal humans alike.
But what kind of ruse was used to deceive you by the powerful one, the one who receives many
guests?”[46]
She [Demeter] was answered by Persephone, the most beautiful:

“So then, Mother, I shall tell you everything, without error.

When the messenger came to me, the swift Argos-killer,

with the news from my father, the son of Kronos, and from the other dwellers in the sky,

that I should come from Erebos, so that you may see me with your own eyes

and let go of your wrath and terrible mênis against the immortals,

then I sprang up for joy, but he, stealthily,

put into my hand the berry of the pomegranate, that honey-sweet food,

and he compelled me by biâ to eat of it.

As for how it was that he [Hadês] snatched me away, through the métis of the son of Kronos,

my father, and how he took me down beneath the depths of the earth,

I will tell you and relate in order, as you ask.

We were, all of us, going along the lovely meadow, I and

Leukippê, Phainô, Elektra, Ianthê,

Melitê, Iakhê, Rhodeia, Kallirrhoê,

Mêlobosis, Tychê, and flower-faced Okyrrhoê,

Chryseis, Ianeira, Akastê, Admêtê,

Rhodopê, Ploutô, and lovely Kalypsô,

Styx, Ourania, and lovely Galaxaura.

Also Pallas [Athena], the one who rouses to battle, and Artemis, who delights in arrows.

We were playing and gathering lovely flowers in our hands,

an assortment of delicate crocus, iris, and hyacinth,

rosebuds and lilies, a wonder to behold,
and the narcissus, which is grown, like the crocus, by the wide earth.[47]
I was joyfully gathering the flowers, and then the earth beneath me

gave way, and there it was that he sprang out, the powerful lord who receives
many guests.
He took me away under the earth in his golden chariot.
It was very much against my will. I cried with a piercing voice.
These things, grieving, I tell you, and they are all alêthea.”
In this way did the two of them spend the whole day, having a like-minded
thûmos,[48]

and they gladdened greatly each other’s heart and thûmos,
hugging each other, and their thûmos ceased having akhos.
They received joy from each other, and gave it.
Then Hekatê approached them, the one with the splendid headband.
And she welcomed back the daughter of holy Demeter with many embraces.

And from that day forward, the Lady [Hekatê] became her [Persephone’s] attendant and
substitute queen.
Then the loud-thundering Zeus, who sees far and wide, sent to them a messenger,
Rhea with the beautiful hair, to bring Demeter, the one with the dark robe,
to join the company of the special group of gods. And he promised tîmai
that he would give to her [Demeter], which she could receive in the company of the immortal
gods.

He [Zeus] assented that her daughter, every time the season came round,
would spend a third portion of the year in the realms of dark mist underneath,
and the other two thirds in the company of her mother and the other immortals.
So he spoke, and the goddess [Rhea] did not disobey the messages of Zeus. Swiftly she darted off from the peaks of Olympus and arrived at the Rarian Field,[49] the life-bringing fertile spot of land, in former times, at least. But, at this time, it was no longer life-bringing, but it stood idle and completely without green growth. The bright grain of wheat had stayed hidden underneath, through the mental power of Demeter, the one with the beautiful ankles. But, from this point on, it began straightaway to flourish with long ears of grain as the springtime was increasing its power. On the field, the fertile furrows began to be overflow with cut-down ears of grain lying on the ground, while the rest of what was cut down was already bound into sheaves. This happened the moment she [Rhea] arrived from the boundless aether. They [Demeter and Rhea] were glad to see each other, and they rejoiced in their thûmos. Then Rhea, the one with the splendid headband, addressed her [Demeter]:

“Come, child, Zeus the loud-thunderer, the one who sees far and wide, is summoning you to come to the company of that special group of gods. And he promised timai that he would give you, which you could receive in the company of the immortal gods. He [Zeus] assented that your daughter, every time the season comes round, would spend a third portion of the year in the realms of dark mist underneath, and the other two thirds in your company and that of the other immortals. He has assented to all this with the nod of his head.[50]
So come, my child! Obey! Do not be too stubborn in your anger at the dark-clouded son of Kronos. Straightaway make the harvest grow, that life-bringer for humans.”

So she spoke, and Demeter, she with the beautiful garlands in her hair, did not disobey. Straightaway she sent up the harvest from the land with its rich clods of earth. And all the wide earth with leaves and blossoms was laden. Then she went to the kings, administrators of themistes, and she showed them—to Triptolemos, to Diokles, driver of horses, to powerful Eumolpos and to Keleos, leader of the people [lāoi]—she revealed to them the way to perform the sacred rites, and she pointed out the ritual to all of them [51]—the holy ritual, which it is not at all possible to ignore, to find out about, or to speak out. The great awe of the gods holds back any speaking out.

Olbios among earth-bound mortals is he who has seen these things. But whoever is uninitiated in the rites, whoever takes no part in them, will never get a share [aisa] of those sorts of things [that the initiated get], once they die, down below in the dank realms of mist. But when the resplendent goddess finished all her instructions, they [Demeter and Persephone] went to Olympus, to join the company of the other gods.

And there they abide at the side of Zeus, who delights in the thunderbolt. Holy they are, and revered. Olbios is he whom they, being kind, decide to love among earth-bound mortals.
Straightaway they send to such a man, to reside at his hearth, in his great palace, Ploutos [Wealth personified], who gives riches to mortal humans.

490 But come, you goddesses, who have charge of the dèmos of Eleusis, fragrant with incense. and of Paros the island and rocky Antron. Come, O lady resplendent with gifts, queen Déô [Demeter], bringer of hôrai, both you and your daughter, the most beautiful Persephone. Think kindly and grant, in return for this song, a rich means of livelihood that suits the thûmos.

495 And I will keep you in mind throughout the rest of my song.
Appendix II: Optogenetics Journal Abstracts


We introduce a method that uses optogenetic stimulation to evoke field potentials in brain slices prepared from transgenic mice expressing channelrhodopsin-2-YFP. Cortical slices in a recording chamber were stimulated with a 473 nm blue laser via either a laser scanning photostimulation setup or by direct guidance of a fiber optic. Field potentials evoked by either of the two optogenetic stimulation methods had stable amplitude, consistent waveform, and similar components as events evoked with a conventional stimulating electrode. The amplitude of evoked excitatory postsynaptic potentials increased with increasing laser intensity or pulse duration. We further demonstrated that optogenetic stimulation can be used for the induction and monitoring of long-term depression. We conclude that this technique allows for efficient and reliable activation of field potentials in brain slice preparation, and will be useful for studying short and long term synaptic plasticity.

*Optogenetic investigation of neural circuits in vivo* Matthew E. Carter and Luis de Lecea

*Trends in Molecular Medicine* April 2011, Vol. 17, No. 4

The recent development of light-activated optogenetic probes allows for the identification and manipulation of specific neural populations and their connections in awake animals with unprecedented spatial and temporal precision. This review describes the use of optogenetic tools to investigate neurons and neural circuits in vivo. We describe the current panel of optogenetic probes, methods of targeting these probes to specific cell types in the nervous system, and strategies of photostimulating cells in awake, behaving animals. Finally, we survey the application of optogenetic tools to studying functional neuroanatomy, behavior and the etiology and treatment of various neurological disorders.
Over the last several years we have developed a rapidly-expanding suite of genetically-encoded reagents (e.g., ChR2, Halo, Arch, Mac, and others) that, when expressed in specific neuron types in the nervous system, enable their activities to be powerfully and precisely activated and silenced in response to light. If the genes that encode for these reagents can be delivered to cells in the body using gene therapy methods, and if the resultant protein payloads operate safely and effectively over therapeutically important periods of time, these molecules could subserve a set of precise prosthetics that use light as the trigger of information entry into the nervous system, e.g. for sensory replacement. Here we discuss the use of ChR2...

Channelrhodopsin-2 (ChR2) is widely used for rapid photodepolarization of neurons, yet, as it requires high-intensity blue light for activation, it is not suited for long-term in vivo applications, e.g. for manipulations of behavior, or photoactivation of neurons during development. We used “slow” ChR2 variants with mutations in the C128 residue, that exhibit delayed off- kinetics and increased light sensitivity in Caenorhabditis elegans. Following a 1 s light pulse, we could photodepolarize neurons and muscles for minutes (and with repeated brief stimulation, up to days) with low-intensity light. Photoactivation of ChR2(C128S) in command interneurons elicited long-lasting alterations in locomotion. Finally, we could optically induce profound changes in animal development: Long-term photoactivation of ASJ neurons, which regulate larval growth, bypassed the constitutive entry into the “dauer” larval state in daf-11 mutants. These lack a guanylyl cyclase, which possibly renders ASJ neurons hyperpolarized. Furthermore, photostimulated ASJ neurons could acutely trigger dauer-exit. Thus, slow ChR2s can be employed to long-term photoactivate behavior and to trigger alternative animal development...

Optogenetic targeting of specific cell populations in rats has not been possible until now. A new study demonstrates a method for creating genetically restricted, recombinase-driven rat lines in which opsins can be expressed in specific populations of neurons. Witten et al. generated tyrosine hydroxylase–Cre lines to target dopaminergic neurons and created choline acetyltransferase–Cre lines to target cholinergic neurons. Optical stimulation of the dopaminergic neurons was sufficient to induce self-stimulation in a model of positive reinforcement. These findings are a promising indicator of the future utility of this approach in rodent models.


To understand the functional role of specific neurons in micro- and macro-brain circuitry, health, and disease, it is critical to control their activity precisely. This ambitious goal was first achieved by optogenetics, allowing researchers to increase or decrease neural activity artificially with high temporal and spatial precision. In contrast to the revolution optogenetics engendered in invertebrate and rodent research, only a few studies have reported optogenetic-induced neuronal and behavioral effects in primates. Such studies are nonetheless critical before optogenetics can be applied in a clinical setting. Here, we review the state-of-the-art tools for performing optogenetics in mammals, emphasizing recent neuronal and behavioral results obtained in nonhuman primates.


In order to understand how the brain generates behaviors, it is important to be able to determine how neural circuits work together to perform computations. Because neural circuits
are made of a great diversity of cell types, it is critical to be able to analyze how these different kinds of cell work together. In recent years, a toolbox of fully genetically encoded molecules has emerged that, when expressed in specific neurons, enables the electrical activity of the targeted neurons to be controlled in a temporally precise fashion by pulses of light. We describe this optogenetic toolbox, how it can be used to analyze neural circuits in the brain and how optogenetics is impacting the study of cognition.


Optogenetics allows millisecond-precision bidirectional control of defined cell types in freely behaving mammals. ChR2-expressing neurons can fire blue light-triggered action potentials, while neurons targeted to express the yellow light-activated chloride pump NpHR can be inhibited from firing action potentials. We also developed VChR1, a redshifted channelrhodopsin that allows testing combinatorial excitation of cell types, as well as light-activated GPCRs (optoXRs) for fast control of biochemical signaling. Through versatile use of microbial opsins, and fiberoptic-laser diode approaches to control specific cell types deep in the brain, we are currently establishing causal relationships between frequency-dependent activity of genetically defined neurons important in neuropsychiatric diseases, and complex orchestrated mammalian behaviors. We have used this approach for investigation of (1) hypocretin/orexin cells in the lateral hypothalamus (2) subthalamic nucleus circuit elements in Parkinsonism (3) dopamine neurons in the VTA to probe the spike parameters causally underlying reward, and (4) parvalbumin neuron behavior relevant to cortical oscillations, schizophrenia and autism.
Molecular Tools and Approaches for Optogenetics. Yuan Mei and Feng Zhang


The mammalian brain poses a formidable challenge to the study and treatment of neuropsychiatric diseases, owing to the complex interaction of genetic, epigenetic, and circuit-level mechanisms underlying pathogenesis. Technologies that facilitate functional dissection of distinct brain circuits are necessary for systematic identification of disease origin and therapy. Recent developments in optogenetics technology have begun to address this challenge by enabling precise perturbation of distinct cell types based on molecular signatures, functional projections, and intracellular biochemical signaling pathways. With high temporal precision and reversible neuromodulation, optogenetics promises to improve existing disease models and advance our understanding of psychiatric conditions. In this review, we describe the current state of molecular optogenetic tools and future directions of development.

Recent advances in optogenetics and pharmacogenetics. Gary Aston-Jones,a,n, Karl Deisserothb.


Optogenetics with microbial opsin genes, and pharmacogenetics with designer receptors, represent potent and versatile experimental modalities that can be integrated with each other as well as with a rich diversity of synergistic methods to provide fundamental opportunities in neuroscience research. The 7th Annual Brain Research Meeting in New Orleans in October 2012, Optogenetics and Pharmacogenetics in Neuronal Function and Dysfunction, brought together leading researchers that have developed and used these tools to explore a wide range of questions in nervous system function and dysfunction. This special issue of Brain Research includes articles by speakers in this meeting and others, which together synthesize and summarize the state of the art for optogenetics and designer receptors.
Reshaping the optical dimension in optogenetics. Alipasha Vaziri and Valentina Emiliani.


Optogenetics has been revolutionizing circuit neuroscience in the last few years. Optical methods combined with genetics and molecular techniques have provided new tools for stimulation of neurons, which hold great promise to provide a solution to the circuit mapping problem and more generally provide us with the ability to artificially control the natural stimulus space. Nevertheless, until very recently almost all applications of optogenetics have been based on relatively simple optical schemes mainly used for inducing population activity in neuronal assembles. In this context, alternative optical schemes that enhance the spatial or temporal resolution of excitation and allow for flexible and arbitrary generation of light patterns have all synergetic impact on the development of new optogenetic actuators. In the following we discuss and compare the main new optical techniques that have become available in the recent years. Their respective strengths and limitations as well as their application to different biological contexts are illustrated.

Optogenetics 3.0. Xu Liu and Susumu Tonegawa,*, The Picower Institute for Learning and Memory, The RIKEN-MIT Center for Neural Circuit Genetics, Department of Biology and Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA, DOI 10.1016/j.cell.2010.03.019.

Optogenetic methods use light to modulate the activities of target cells in vivo. By improving inter- and intracellular trafficking of light-sensitive switch proteins called opsins, Gradinaru et al. (2010) have developed a new generation of optogenetic tools capable of regulating the activity of targeted neurons with exquisite precision and efficiency.
Optogenetics is a rapidly evolving field of technology that allows optical control of genetically targeted biological systems at high temporal and spatial resolution. By heterologous expression of light-sensitive microbial membrane proteins, opsins, cell type-specific depolarization or silencing can be optically induced on a millisecond time scale. What started in a petri dish is applicable today to more complex systems, ranging from the dissection of brain circuitries in vitro to behavioral analyses in freely moving animals. Persistent technical improvement has focused on the identification of new opsins, suitable for optogenetic purposes and genetic engineering of existing ones. Optical stimulation can be combined with various readouts defined by the desired resolution of the experimental setup. Although recent developments in optogenetics have largely focused on neuroscience it has lately been extended to other targets, including stem cell research and regenerative medicine. Further development of optogenetic approaches will not only highly increase our insight into health and disease states but might also pave the way for a future use in therapeutic applications.
Appendix III: AXIOM Questionnaire

Please select the answer that best matches your understanding of the video:

what is the scientist trying to accomplish?

A) to save the killer whale

B) to take over the world

C) to preserve genetic information and synthetically restore biodiversity

D) to communicate with plants

E) other:______________________________________________________

why does the scientist panic?

A) she forgot to remove the infected microchip

B) she is synchronizing with the virtual archive

C) she has a dissociative fugue

D) because all of her data disappeared

E) other:______________________________________________________

what is H.A.D.E.S.?

A) i have no idea

B) the greek realm of the dead

C) the scientist's initials

D) the virtual environment

E) other:______________________________________________________

why does the system malfunction?

A) an unknown seed is spontaneously spawned
B) the battery died
C) the data was corrupt
D) the password was wrong
E) other: ____________________________________________________________

how does the story end?

A) the system is repaired
B) it was all a dream
C) the new seed is transported to reality
D) happily ever after
E) other: ____________________________________________________________
Appendix IV: PIXAR PROCESS
Appendix V: AXIOM PROCESS
Appendix VI: AXIOM STILLS
Bibliography:


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