Years:	Norbert Wiener (1928 - 2007)	Bill Nichols (1942 -)	Heinz.Von Foerster (1911 - 2002)	Jakob von Uexkull (1864 - 1944)	Harold Cohen (1928 -)	Simon Penny (1955 -)	Edward Shanken (1964 -)	Stephen Wilson (1945 - 2011)		
Affiliations:	**Mathematician & Philosopher,**	**American Film Critic, Theoretician** **SF STATE**	**Scientist: Physics & Philosophy**	**Biologist**	**Artist, Computational Artist** **UCSD**	**Artist, Theorist, Curator (New Media Art)** **UCI**	**Art Historian** **Duke**	**Artist, Theorist (New Media Art)**		**SF STATE**
Article:	**Men, Machines, and the World About: (1954)**	**The Work of Culture in the Age of Cybernetic Systems: (1988)**	**Understanding understanding, Essays on Cybernetics and Cognition: On Self Organizing Systems and Their Environments (1959)**	**An Introduction to Unwelt: (1938)**	**On the Purpose: An Enquiry into the Possible roles of the Computer in Art (1973)**	**Experience and Abstraction: the Arts and the Logic of Machines (2008)**	**Art And Electronic Media Survey: (2009)**	**Information Arts: Intersections of Art, Science, and Technology** **Ch. 1.1** **Art and Science as Cultural Acts (2001)**	**Information Arts: Intersections of Art, Science, and Technology** **Ch. 3.3** **Materials and Natural Phenomena: Nonlinear Dynamic Systems, Water, Weather, Solar Energy, Geology and Mechanical Motion (2001)**	**Information Arts: Intersections of Art, Science, and Technology** **Ch. 3.4** **Space (2001)**
Ph.D. Research:	*Cybernetics*	*Cybernetics & Media Theory*	*Cybernetics and Systems Theory*	*Cybernetics*	Aesthetics & Computer Arts,	Media Arts and Technology	Media Arts and Technology: History and Archeology	Media Arts and Technology: History and Archeology		
Keywords: Theory	*(Cybernetics) –* *Creation of a new field of study.* *Greek word κυβερναν meaning to govern, as essentially the art of the steersman.*	*Cybernetics & Media Theory*	*Cybernetics, Entropy* *Self Organizing Systems & Environments (space)*	*(Biological Cybernetics) - Cybernetics Umwelt*	Computer Art, Computational Arts: Aaron: a computer program designed to produce art autonomously	Art, Computation, Electronic Art, New Media Art, Robotics, & Virtual Reality,	Art History: work focuses on the entwinement of art, science and technology, with a focus on experimental new media art and visual culture.	Artist, New Media Art:		
Reference: (Terms)	*Cybernetics, Systems Control, Water Clock, Teleological Mechanisms, Governor (device), Evolution, Umwelt, Artificial Intelligence, New Cybernetics, Complex Adaptive Systems, Complex Systems, Computational Complexity theory*	*Cybernetics, Babyz, The Sims, Eliza, Psychopathology, Extolled, Hermeneutic, Zero-sum game,*	*Cybernetics, Self Organization, SELF-ORGANIZING SYSTEM, Entropy, Thermodynamics, Laws of thermodynamics, Heat Death, What is Life? , Information Theory*	*Biosemiotics, Biocybernetics, Cybernetics, Theoretical Biology, Umwelt* *Associative Terms:* *Biogenetic Structuralism, Cognized environment, Reality Tunnel*		*Symbolic Computation, Object oriented programming, Skeuomorph, Gestell (Enframing), Ontology, Autopoiesis*	**-Illumination:** *Olafur Eliasson"TheWeatherProject"03* **-Coded:** *Ryoji Ikeda, "datamatics" 06* **-Charged Environments:** *George Legrady"Making the Invisible Visible, 04* **-Culture Jamming:** *Randall Packer "US Department of Art & Technology* **-Emergent Systems:** *Ken Rinaldo "AutoPoesis" 00* *Christa Sommerer & Laurent Mignonneau "A-Volve" 94/95* **-Simulations And Simulacra** *Marcos Novak "Liquid Architectures" 91* *Mary Flanagan [domestic], 03*			
Influential Thinkers:	Norbert Wiener, Plato, André-Marie Ampère, Ctesibius, James Watt, Alfred Russel Wallace, James Clerk Maxwell, Claude Bernard, Jakob von Uexkull	*Walter Benjamin, Gregory Bateson, George Bataille, Anthony Wilden*	*Gordon Pask, Ludwig Boltzmann, Claude Shannon, Erwin Schrodinger*	*Martin Hiedegger & Thomas Sebeok.*		*Martin Hiedegger & Rene Decartes*			*Turbulent Landscapes @ the Exploratorium* *Ned Khan "Turbulent Landscapes"* *Ken Goldberg "Mori" Installation* *Project Taos "BeWare"* *Walter De Maria "Lightning Field"* *Robert Mulder & Kristi Allik "Millennium Project"* *Nicholas Negroponte "Being Digital"*	*Albert Molina "Leonardo" & "The role of the Artist in Space Exploration:* *Tom Van Sant "GeoSphere"* *Arthur Wood "Cosmic Dancer" & "Ours 2000"* *Monumental Space Art:* *Marko Peljhan "MAKROLAB" study of the Aurora Borealis.* *Search for Extra Terrestrial Intelligence (SETI)*
Objectives:	*The objectives are to explain the history of Cybernetics, its beginnings and new found insights in the creation of a new discipline and the study of the biological machine.*	*To outline the extent that cybernetics has become the main operating metaphor of globally.*	*To demonstrate that systems theory is demonstrated by the phenomenon of "Self-Organizing Systems" and the relationship to their environments.*	*All living things have levels of awareness through the living beings sensorial spheres. Humans are the only species that can decenter itself through its awareness of other factors that shift reality from the senses.*	*Artists and machines can have meaningful collaborations if the artist knows the machines limitations and potential both theoretically and through artworks.*	*This paper is thus a call to a Critical Technical Practice in Digital Cultural Practices*	The serious artist is the only person able to encounter technology with impunity, just because he is an expert aware of the changes in sense perception. …artists use, re-purpose and invent electronic media in ways that delight the senses, baffle the mind and offer profound insights into the implications – both positive and negative – of techno-culture. Although electricity has become so ubiquitous as to be mundane, artists continue to discover its poetic significance, if not magic. In doing so, they simultaneously humanize and mythologize electronic media, transforming it through artistic alchemy to stretch the imagination, expand consciousness and inspire others to new levels of creativity and invention.	Information Arts takes an unorthodox look at this question, focusing on the revolutionary work of artists and theorists who challenge the separations initiated in the Renaissance. It points toward a possible future in which the arts can reassume their historical role of keeping watch on the cultural frontier and in which the sciences and arts inform each other. ..Scientific and technological research should be viewed more broadly than in the past: not only as specialized technical inquiry, but as cultural creativity and commentary, much like art.	This chapter considers artists who continue this tradition influ- enced by the ideas, insights, and perspectives of contemporary physical sciences. It con- siders artists who are fascinated by nonlinear systems, the mechanics of motion, and geological and solar phenomena.	Astronomical and cosmological research and space science promise to have great impact on humanity. Historically, the arts paid close attention to the heavens. Some artists have started the effort. NASA even sponsors a limited Space Art project. Several organizations around the world promote artistic involvement, such as OURS Foundation, Journal Leonardo Space Project, and Ars Astronautica.
Main Argument:	*Human beings connected between a system of machines can be replaced through a process of analysis, quantification and reverse engineering of the biological/human machine. Example used Gunman from an Antiaircraft gun from WWII.*	*I want to ask how the preoccupations of a cybernetic imagination have gained institutional legitimacy in areas such as the law. In this case, like others, a tension can be seen to exist between the liberating potential of the cybernetic imagination and the ideological tendency to preserve the existing form of social relations. I will focus on the work of culture—its processes, operations, and procedures—and I will assume that culture is of the essence: Pg. 627*	*That "self organizing systems are dependent on their environment", this can be defined from the observation of the energy and resources in the system. The examples used are from the understanding of the laws of thermodynamics and entropy.*	*Creating a fundamental understanding of all living things, level of awareness and quantifying the spheres of the senses. The paper is demonstrating that by these senses that our perceptions are common experiences to others should not be assumed based on age, gender or even spatial relations. This sense of perception is key in the basic understanding of how to plan to universalize environments.*		*The main thesis of the article is that embodied art practice (fine arts) and its relationship with logical, numerical and textual abstractions (computation) are operating on different paradigms. A new language and synthesis of production methodologies are required. The different innate qualities and processes must be quantified carefully for new media arts practice and research inquiry to be more rigorous and embodied with intent.*	Artists have combined the arts, technology and science to blur the lines between living matter and non living matter. Using cybernetics to hack and communicate with plants and insects. To see the limits of communication and interaction between species…..Robots are used as not only surrogates in action but in purpose. Scenarios of survival and the evaluation of such systems are inherent of some of the works….. Revealing the hidden nature of material. ….Virtual reality technologies essence is to immerse bodies in space and to formalize a symbolic language. This formalization of space, technology, science and aesthetics creates the sense of immersion. The capacity of which can be seen since its discovery in the 1960's as a beginning of the full integration of immersive information and the ability to communicate spatial data.This technology bridges bits and bytes. …..Exhibitions were created by community members that wanted to collaborate on larger projects. The collaborations created partnerships in sharing resources that only were available by companies, research universities and Museums/ Inventors. The unification and the creation of the field of new media and art/science collaboration was a movement out of need to find ways of making. Making beyond individual limitations.	The Chapter by Stephen Wilson is defining terms. Asking fundamental questions about how the merging of Art, Science and Technology will redefine and influence culture. The chapter was an explanation and the outline of how technology and arts can unify with technology to scrutinize what is either being produced by the medium, how it is represented and what it creates. This relationship can be seen as either perpetuating a past agenda or a creation of a new way to create knowledge. The characteristics of the mediums that incorporate science can be either technical in nature or focus on the system of knowledge creation privileged by the "why" of knowledge creation.	The article discussed the opportunities with Non linear systems. And the links between artists and scientists interested in natural systems. Nature as a force for inspiration and to same what is chaotic and finding order from the signals / data. The bit and the ego are united conceptually through information. This section is declaring that the materiality of the universe is fundamental to the Atom. All artists in this section use nature as a parameter to either create a dynamic system or to use it as a metaphor to flow other mediums through (information)	In the chapter of space it is clear that the interest is not only the phenomenological interest but also the implications to humanities vision of itself. The interest in using the material of space, the philosophical implications of space are enabled by the art work that strives to overcome the limitations of this new scale. The awareness of this new condition that humanity has found through will of technology, is now grappling with the time scales and the mortality of the species. The planet has an end point and so does the universe, but the expression of using this domain / science is the rational means that artist and scientists have time to imagine a world that is fully integrated by the condition of weightlessness and not of gravity and air. All fundamental understandings of space as well as virtual space is an instinctual condition that expresses the opportunity and the challenges that passing the threshold of a body that is oriented by forces is not bound in one direction. The multiple directions of all particles atoms and bits needs an understanding that the knowledge of scales and existence must be layered and focused on the awarenesses of all senses and forms of consciousness.
Summary: Quotes:	A.	B.	C.	D.	E.	F.	-Preface: (pg. 10) -Survey: (pg. 12) -Motion, Duration, Illumination (pg. 16) -Coded Form and Electronic Production (pg. 22) -Charged Environments (p. 27) -Networks, Surveillance, Culture Jamming (p. 32) -Bodies, Surrogates and Emergent Systems (p. 38) -Simulations And Simulacra (p. 42) -Exhibitions, Institutions, Communities, Collaborations, (p. 47)	-Historical Separations -The Urgency for Reexamination -Organization of the Book -The Deficiency of Categorization -How Does Research Function in Various Artists' Works? -What Areas of Technological Art Are Included? Which Are Not? -What Is Technology? What Is High-tech Art?(pg.9) -The Assimilation of Art into Research and Commercial Production -Definitions and Theoretical Reflections -What is Science? (pg. 12) -What Is Technology? (pg. 13) -What Is Art? (pg. 16) -Similarities and Differences between Science and Art (pg. 18) -Critical Theory and Problematic Issues in the Integration of Art and Techno- -Scientific Research (pg. 20) -Disjunctions between Scientific Worldviews and Critical Theory (pg. 21) -The Status of Substantive Things and Organisms -in a World Dominated by Image and Media(pg.23) -The Difficulties of Locating a Rationale for Action in a Deconstructed Milieu (pg. 25) -Artists' Stances in Integrating Research (pg. 25) -Continuing the Modernist Practice of Art with Modificationsfor the Contemporary Era (pg. 26) -Deconstruction as Art Practice(pg. 27) -Invention and Elaboration of New Technologies and Their Cultural Possibilities as -Art Practice (pg. 28) -Summary: The End of Timelessness? (pg. 30)	−Introduction: (p. 235) −Nonlinear Systems (p. 235) −"Turbulent Landscapes" at the Exploratorium and the InterCommunication Center (p. 235) −Ned Kahn (p. 237) −Natural Phenomena—Oceans, Water, and Moving Liquid (p. 239) −Natural Phenomena—Erosion and Geological Action (p. 241) −Natural Phenomena—The Sky, Winds, and Weather (p. 244) −Solar Art (p. 246) −Mechanics—Oscillation and Pendulum Action (p. 251) −Fire, Heat, Magnetics, and Electromagnetics (p. 253) −Materials Science, Rapid Prototyping, and Chemistry (p. 253) −Summary: Pattern Finding and Poetry of Matter (p. 256) −Bits vs. Atoms—The Future of Phenomena-Based Art (p. 258)	-Artistic Interest in Space (p. 261) -Views from Space (p. 263) -Pierre Comte -Tom Van Sant—GeoSphere -Art Viewed from Earth -Joe Davis, Arthur Woods, Jean-Marc Philippe, and Richard Clar -Scientific and Public Objections to Space Art (p. 267) -Art Executed in Space and Weightlessness (p. 267) -Painting and Photography Based on Space Exploration (p. 271) -Conceptual and Electronic Works (p. 271) -Search for Extra Terrestrial Intelligence (SETI) (p. 275) -Art Critiques of Space Research (p. 278) -Summary: The Hopes (p. 279)

	Norbert Wiener	Bill Nichols	Heinz.Von Foerster	Jakob von Uexkull	Harold Cohen	Simon Penny
Years:	(1928 - 2007)	(1942 -)	(1911 - 2002)	(1864 - 1944)	(1928 -)	(1955 -)
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Article:	**Men, Machines, and the World About: (1954)**	**The Work of Culture in the Age of Cybernetic Systems: (1988)**	**Understanding understanding, Essays on Cybernetics and Cognition: On Self Organizing Systems and Their Environments (1959)**	**An Introduction to Unwelt: (1938)**	**On the Purpose: An Enquiry into the Possible roles of the Computer in Art (1973)**	**Experience and Abstraction: the Arts and the Logic of Machines (2008)**
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Keywords: Theory	*(Cybernetics) – Creation of a new field of study. Greek word κυβερναν meaning to govern, as essentially the art of the steersman.*	*Cybernetics & Media Theory*	*Cybernetics, Entropy Self Organizing Systems & Environments (space)*	*(Biological Cybernetics) - Cybernetics Umwelt*	Computer Art, Computational Arts: Aaron: a computer program designed to produce art autonomously	Art, Computation, Electronic Art, New Media Art, Robotics, & Virtual Reality,
Reference: (Terms)	*Cybernetics, Systems Control, Water Clock , Teleological Mechanisms, Governor (device), Evolution, Umwelt, Artificial Intelligence, New Cybernetics, Complex Adaptive Systems, Complex Systems, Computational Complexity theory*	*Cybernetics, Babyz, The Sims, Eliza, Psychopathology, Extolled, Hermeneutic, Zero-sum game,*	*Cybernetics, Self Organization, SELF-ORGANIZING SYSTEM, Entropy, Thermodynamics, Laws of thermodynamics, Heat Death, What is Life? , Information Theory*	*Biosemiotics, Biocybernetics, Cybernetics, Theoretical Biology, Umwelt Associative Terms: Biogenetic Structuralism, Cognized environment, Reality Tunnel*		*Symbolic Computation, Object oriented programming, Skeuomorph, Gestell (Enframing), Ontology, Autopoiesis*
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Objectives:	*The objectives are to explain the history of Cybernetics, its beginnings and new found insights in the creation of a new discipline and the study of the biological machine.*	*To outline the extent that cybernetics has become the main operating metaphor of globally.*	*To demonstrate that systems theory is demonstrated by the phenomenon of "Self-Organizing Systems" and the relationship to their environments.*	*All living things have levels of awareness through the living beings sensorial spheres. Humans are the only species that can decenter itself through its awareness of other factors that shift reality from the senses.*	*Artists and machines can have meaningful collaborations if the artist knows the machines limitations and potential both theoretically and through artworks.*	*This paper is thus a call to a Critical Technical Practice in Digital Cultural Practices*
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Summary: Quotes:	**A.**	**B.**	**C.**	**D.**	**E.**	**F.**

Edward Shanken
(1964 -)

Art Historian

Duke

Art And Electronic Media Survey: (2009)

Media Arts and Technology:
History and Archeology

Art History: work focuses on the entwinement of art, science and technology, with a focus on experimental new media art and visual culture.

-Illumination:
Olafur Eliasson"TheWeatherProject"03
-Coded:
Ryoji Ikeda, "datamatics" 06
-Charged Environments:
George Legrady"Making the Invisible Visible, 04
-Culture Jamming: *Randall Packer "US Department of Art & Technology*
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Christa Sommerer & Laurent Mignonneau "A-Volve" 94/95
-Simulations And Simulacra
Marcos Novak "Liquid Architectures" 91
Mary Flanagan [domestic], 03

The serious artist is the only person able to encounter technology with impunity, just because he is an expert aware of the changes in sense perception.
..artists use, re-purpose and invent electronic media in ways that delight the senses, baffle the mind and offer profound insights into the implications – both positive and negative – of techno-culture. Although electricity has become so ubiquitous as to be mundane, artists continue to discover its poetic significance, if not magic. In doing so, they simultaneously humanize and mythologize electronic media, transforming it through artistic alchemy to stretch the imagination, expand consciousness and inspire others to new levels of creativity and invention.

Artists have combined the arts, technology and science to blur the lines between living matter and non living matter. Using cybernetics to hack and communicate with plants and insects. To see the limits of communication and interaction between species…..Robots are used as not only surrogates in action but in purpose. Scenarios of survival and the evaluation of such systems are inherent of some of the works….. Revealing the hidden nature of material.
….Virtual reality technologies essence is to immerse bodies in space and to formalize a symbolic language. This formalization of space, technology, science and aesthetics creates the sense of immersion. The capacity of which can be seen since its discovery in the 1960's as a beginning of the full integration of immersive information and the ability to communicate spatial data.This technology bridges bits and bytes.
…..Exhibitions were created by community members that wanted to collaborate on larger projects. The collaborations created partnerships in sharing resources that only were available by companies, research universities and Museums/ Inventors. The unification and the creation of the field of new media and art/science collaboration was a movement out of need to find ways of making. Making beyond individual limitations.

Stephen Wilson
(1945 - 2011)

Artist, Theorist (New Media Art)

SF STATE

Information Arts: Intersections of Art, Science, and Technology Ch. 1.1 Art and Science as Cultural Acts (2001)

Media Arts and Technology:
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Information Arts takes an unorthodox look at this question, focusing on the revolutionary work of artists and theorists who challenge the separations initiated in the Renaissance. It points toward a possible future in which the arts can reassume their historical role of keeping watch on the cultural frontier and in which the sciences and arts inform each other.
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The Chapter by Stephen Wilson is defining terms. Asking fundamental questions about how the merging of Art, Science and Technology will redefine and influence culture.

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The characteristics of the mediums that incorporate science can be either technical in nature or focus on the system of knowledge creation privileged by the "why" of knowledge creation.

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Turbulent Landscapes @ the Exploratorium
Ned Khan "Turbulent Landscapes"
Ken Goldberg "Mori" Installation
Project Taos "BeWare"
Walter De Maria "Lightning Field"
Robert Mulder & Kristi Allik "Millennium Project"
Nicholas Negroponte "Being Digital"

This chapter considers artists who continue this tradition influ- enced by the ideas, insights, and perspectives of contemporary physical sciences. It con- siders artists who are fascinated by nonlinear systems, the mechanics of motion, and geological and solar phenomena.

The article discussed the opportunities with Non linear systems. And the links between artists and scientists interested in natural systems. Nature as a force for inspiration and to same what is chaotic and finding order from the signals / data. The bit and the ego are united conceptually through information.

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Information Arts: Intersections of Art, Science, and Technology Ch. 3.4 Space (2001)

Albert Molina "Leonardo" & "The role of the Artist in Space Exploration:
Tom Van Sant "GeoSphere"
Arthur Wood "Cosmic Dancer" & "Ours 2000"
Monumental Space Art:
Marko Peljhan "MAKROLAB" study of the Aurora Borealis.
Search for Extra Terrestrial Intelligence (SETI)

Astronomical and cosmological research and space science promise to have great impact on humanity. Historically, the arts paid close attention to the heavens.

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In the chapter of space it is clear that the interest is not only the phenomenological interest but also the implications to humanities vision of itself.

The interest in using the material of space, the philosophical implications of space are enabled by the art work that strives to overcome the limitations of this new scale. The awareness of this new condition that humanity has found through will of technology, is now grappling with the time scales and the mortality of the species. The planet has an end point and so does the universe, but the expression of using this domain / science is the rational means that artist and scientists have time to imagine a world that is fully integrated by the condition of weightlessness and not of gravity and air.

All fundamental understandings of space as well as virtual space is an instinctual condition that expresses the opportunity and the challenges that passing the threshold of a body that is oriented by forces is not bound in one direction. The multiple directions of all particles atoms and bits needs an understanding that the knowledge of scales and existence must be layered and focused on the awarenesses of all senses and forms of consciousness.

Art And Electronic Media (Edward Shanken) Survey pp. 12-53 (41)

Links:

- ☐ _Article Summary:
  - ☐ Art And Electronic Media
  - ☐ Author: Edward Shanken
  - ☐ Art And Electronic Media (Edward Shanken)
    Preface & Survey pp. 12-53 (41)
  - ☐ Year: 2003
  - ☐ Publisher: Phaidon Press (February 21, 2009)
- ☐ _Glossary
  - ☐ Major Concepts:
    - ☐ Cybernetic Arts:
  - ☐ Terms
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
      - ☐ Roy Ascott — royascott.net
      - ☐ Harold Cohen — www.aaronshome
      - ☐ Ben F. Laposky — en.wikipedia.org–
      - ☐ Max Bense — en.wikipedia.org–
      - ☐ Garnet Hertz: — www.conceptlab.c
    - ☐ Concepts
    - ☐ Online Sources:
- ⊟ _Outline
  - ⊟ **Preface: (pg. 10)**
    - ☑ Artists have always used the most advanced materials and techniques to create their work.
    - ☐ When their visions required media and methods that did not exist, they invented what was needed to realize their dreams.
    - ☐ as with oil paint in the 1400s and with photography five centuries later, a new technology became so widely adopted that it gained acceptance as a conventional artistic medium.
    - ☐ In our own time, electronic technologies have become so pervasive that it is hard to imagine contemporary contemporary music produced without electric instruments or to imagine an author writing or an architect designing without the aid of a computer.
  - ☐ **Survey: (pg. 12)**
    - ☐ *Introduction: (pg. 13)*
      - ☐ The serious artist is the only person able to encounter technology with impunity, just because he is an expert aware of the changes in sense perception.
      - ☐ …artists use, re-purpose and invent electronic media in ways that delight the senses, baffle the mind and offer profound insights into the implications – both positive and negative – of techno-culture. Although electricity has become so ubiquitous as to be mundane, artists continue to discover its poetic significance, if not magic. In doing so, they simultaneously humanize and mythologize electronic media, transforming it through artistic alchemy to stretch the imagination,

expand consciousness and inspire others to new levels of creativity and invention.

- ⊟ **Motion, Duration, Illumination (pg. 16)**
  - ☐ *Introduction:*
    - ☐ *Defying the traditional conception of art as a static object, in the early twentieth century artists began to introduce actual motion into their work, making explicit the continuity of consciousness in the perception of art through time and space. Artists using artificial light such as neon or laser as a medium explored the immateriality of form and color, freeing art from its dependence on external illumination by making it an actual light source in its own right. In the 1920s and 1930s, László Moholy-Nagy joined motion and illumination, a combination that inspired artists associated with various nouvelle tendence collectives to create light-infused, kinetic environments. Later, in the 1950s, embracing the science of cybernetics, Nicolas Schöffer collaborated with engineers to incorporate electronic sensors, controls and motors into sculptures that responded to the movement of viewers, performers or atmospheric conditions. Such works laid a significant foundation for subsequent developments in interactive art incorporating digital multimedia.*
  - ☐ *Works:*
    - ☐ *László MOHOLY-NAGY Light-Space Modulator, 1923–30 page 55*
      Naum GABO Kinetic Construction (Standing Wave), 1919–20 page 56
      Thomas WILFRED Opus 161, 1965–6 page 57
      Lucio FONTANA Ninth Triennial of Milan Grand Staircase, 1951
      Gyorgy KEPES Light Mural for KLM, 1959 page 58
      Gyula KOSICE Estructura Lumínica Madí 'F', 1946
      Abraham PALATNIK Cinechromatic, 1951 page 60
      Frank MALINA Point Counter Point, 1956 page 60
      Otto PIENE Light Ballet, 1959–60 page 61
      Nicolas SCHÖFFER CYSP I, 1956 page 62
      TAKIS Signal Lumineux, 1958 page 63
      Dan FLAVIN Greens Crossing Greens: to Piet Mondian Who Lacked Green, 1966
      James TURRELL Catso, Red, 1967, 1994 page 65
      Mario MERZ Igloo di Giap (Se il nemico si concentra perde terreno se si disperde perde forza) ['Giap's Igloo (If the enemy concentrates, he loses ground, if he scatters, he loses force)'], 1968 Jean DUPUY Heart Beats Dust, 1968 page 66
      Jean DUPUY Heart Beats Dust, 1968 page 66
      James SEAWRIGHT Electronic Peristyle, 1968 page 66
      Vladimir BONACIĆ G.F.E., 1969–71 page 67
      Rockne KREBS Day Passage, 1970 page 68
      Alejandro and Moira SIÑA Spinning Shaft, 1978 page 69
      Mary LUCIER Dawn Burn, 1973 page 70
      Gary HILL Soundings, 1979 page 70
      Shawn BRIXEY and Laura KNOTT Photon Voice, 1986 page 71
      Nam June PAIK Video Flag Y, 1985 page 71
      Tatsuo MIYAJIMA Clock for 300 Thousand Years, 1987 page 72
      Paul DEMARINIS Edison Effect, 1989 page 73
      Jenny HOLZER Untitled (selections from Truisms, Inflammatory Essays, The Living Series, The Survival Series, Under a Rock, Laments and Child Text), 1989 page 73

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- ☐ *Documents:*
  - ☐ *Naum GABO and Anton PEVSNER The Realistic Manifesto, 1920 page 193*
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    Erkki HUHTAMO Resurrecting the Technological Past: An Introduction to the Archeology of Media Art, 1995 Jürgen CLAUS Stan VanDerBeek: An Early Space Art Pioneer, 2003 page 201
- ⊟ *Review:*
  - ☑ Traditional visual art is static: it captures or represents a moment in time. Moreover, it typically depends on a light source for illumination.
  - ☐ Electronic media facilitate the liberation of art from conventional stasis and provide a means for it to consist of light itself.
  - ☐ Since the early twentieth century, artists have used neon, fluorescent, laser and other forms of electric light as bona fide artistic media, often in ways that incorporate motion and time. Paralleling the intrinsic temporality of music and cinema, artists increasingly have set art in motion in such a way that the work can only properly be perceived as a durational experience. Indeed, the traditions of experimental music and film, along with the use of sound and moving images, have become increasingly incorporated into contemporary art practices,particularly those involving electronic media.
  - ☐ Metaphors from chronophotography and cinema were employed by philosophers Henri Bergson and Henry James to theorize vitality and duration with respect to human perception and consciousness.
  - ☐ In particular, Bergson's *Matter and Memory* (1896) and *Creative Evolution* (1907) have been singularly influential philosophical texts among artists, specially many associated with Cubism and Futurism.
  - ☐ …questions pertaining to the nature and perception of time, space, motion and light form a nexus at which the inquiries of art, science and philosophy have become increasingly interwound.
  - ☐ Alongside the visual exploration of motion and time, artists have studied the way light falls on objects creating shadows, as well as the way light illuminates artworks in the particular settings where they are installed.
  - ☐ The chiaroscuro technique of light and dark shading that reached maturity during the Renaissance emulates three-dimensionality on a two- dimensional plane by mimicking how light falls on solid objects.

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- ☐ …T*he Conversion of St. Paul on the Way to Damascus* (1601), Caravaggio depicts the instant of the saint's epiphany upon falling from his horse as if illuminated by a sudden burst of divine light. His technique, a high-contrast form of chiaroscuro known as tenebroso, achieves effects that bear an uncanny resemblance to Edgerton's high-speed flash photography.
- ☐ Bernini designed the *Ecstasy of St. Theresa* (1647–52)….Actual light thus becomes an integral part of the work, functioning as a protagonist in the dramatic scene.
- ☐ A combination of technological and scientific developments in the nineteenth century resulted in new understandings of light and visual perception, provoking significant changes in art.
- ☐ Amidst the popularization of photography, many artists shifted focus from rendering likenesses of objects and the effects of light on them to capturing and giving visual form to the sensate experience of how light affects the human eye.
- ☐ Impressionist painting, for example, was bound up in contemporary views on the physiology and phenomenology of perception that emphasized the mediation of vision through the eyes and brain, suggesting an element of subjectivity.
- ☐ Combined with the faddish success of stereo-photography in the 1870s and 1880s, the popular understanding of vision shifted from a simple 1:1 correspondence between an object and its perception by the viewer to a conception of vision as the result of light reflecting off an object, entering each of the viewers' eyes from slightly different angles and being processed by their brains into a single, composite image that offered a sense of depth.[1]
- ☐ In this way, Impressionism, and later, Pointillism, demanded that viewers play an active role in the perception of art, a prevailing ethos of contemporary interactive art.
- ☐ Similarly, contemporary artists including Olafur Eliasson, Robert Irwin, Ulf Langheinrich and James Turrell have created work that examines the perceptual limits of the human visual system.
- ☐ …t was not until around 1920 that artists made works that moved or that were sources of light.
- ☐ Such kinetic artworks extended the frame of art by breaking with two forms of stasis: spatial and temporal.
- ☐ Art no longer stood still in space or time.
- ☐ Freed of frame and pedestal, animated by electricity, it could move about in the space of the viewer or the environment, modulate between various states or take on a new identity that required four dimensions to envision and experience.
- ☐ Whereas cubist and futurist art theories sought to draw the viewer into an aesthetic experience that implied movement and time,
- ☐ around 1920 Thomas Wilfred, Marcel Duchamp, Naum Gabo and László Moholy-Nagy began using electronic elements to make motion and duration explicit and essential characteristics of their work.
- ☐ Building on an enduring fascination with synaesthesia and light-organs, notably those of precursor Louis-Bertrand Castel in the eighteenth century,

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- ☐ the first public demonstration of Wilfred's Clavilux in 1922 was performed using a keyboard that controlled six projectors and an array of reflectors, enabling the artist to modulate the movement, hue and intensity of light on the screen. Wilfred later created and sold individual Lumia cabinets, the visual equivalent of player-pianos, that displayed predetermined arrangements of coloured light that he composed,
- ☐ such as *Aspiration*, comprised of 397 variations with a total duration of 42 hours, 14 minutes and 11 seconds.[2]
- ☐ These devices anticipated the kinetic paintings of Abraham Palatnik and Frank Malina in the 1950s, light shows at rock concerts beginning in the 1960s and visualization software that transforms MP3 files into undulating patterns on PCs in the 2000s.
- ☐ Gabo's *Kinetic Construction* (1920) produced a virtual volume only when activated, thereby making motion a necessary feature of the art object and further emphasizing temporality.
- ☐ Indeed, the term 'kinetic' was first used in connection with visual art by Gabo and his brother Anton Pevsner in their *Realistic Manifesto* dating from the same year (Documents, 193)
- ☐ Duchamp's *Nude Descending a Staircase* (1912) and *Bicycle Wheel* (1913) anticipated subsequent research on the perception of actual motion in the 1920s. Powered by an electric motor, his *Rotary Glass Plates (Precision Optics)* (1920) incorporated a series of five painted glass plates mounted on a motorized shaft. Spinning at high speeds, it created the appearance of concentric circles on a single plane when viewed at a distance of one metre. The work thus required motion and time to produce this perceptual effect in the viewer.
- ☐ Electric motors in Moholy-Nagy's *Light-Space Modulator* (1923–30; Works, 55) set the shiny steel sculpture in motion while electrical illumination in the gallery reflected light off it and into its surroundings. The *Light Prop*, as it also is known, not only pushes the temporal dimensions of art but expands its spatial dimensions into the entire environment, including the viewer, who becomes a surface onto which light is reflected.
- ☐ In *The New Vision* (1928), Moholy-Nagy advocated pushing art beyond static forms and introducing kinetic elements, 'in which the volume relationships are virtual ones, i.e., resulting mainly from the actual movement of the contours, rings, rods, and other objects.... To the three dimensions of volume, a fourth – movement – (in other words, *time* is added).'[3].
- ☐ With respect to light, he noted that 'light – as time-spatial energy and its projection – is an outstanding aid in propelling kinetic sculpture and in attaining virtual volume.'
- ☐ Vladimir Tatlin's design for the *Monument to the Third International* (1919–1920) proposed a 400 metre spiral structure comprised of three levels revolving at different speeds: a cube-shaped conference centre turning at the rate of one revolution a year; a pyramid for administrative offices revolving once a month; and an information centre cylinder completing one revolution per day.
- ☐ The idea of putting art in motion began to spread in the early 1930s, when Alexander Calder's mobiles were first exhibited in Paris and New York. By

the 1950s and 1960s artists throughout North and South America and Eastern and Western Europe began experimenting with duration, light and motion.[5]

- ☐ 1955 bore two important exhibitions: 'Man, Machine, and Motion', curated by artist Richard Hamilton at the Institute of Contemporary Arts (ICA) in London; and 'Le Mouvement', curated by K.G. Pontus Hultén at the Galerie Denise René in Paris and including work by a highly diverse group of artists from around the world, such as Duchamp, Calder, Victor Vasarely, Agam, Pol Bury, Jesús Rafael Soto, Jean Tinguely, Gyorgy Kepes and Robert Breer.
- ☐ publication by Vasarely and Hultén of the *Yellow Manifesto*, which played an important role in popularizing the term, 'Kinetic Art', to refer to this growing international movement.
- ☐ The growing acceptance of electric light as an artistic medium can be observed through an exploration of recent art history. From Neo-Constructivism and New Tendency to Arte Povera, Postminimalism and Conceptual Art, artists have used the vernacular of neon to wield the eye-catching brilliance…On the symbolic significance of neon as an artistic medium, Merz wrote: *Light is nevertheless technological energy in the making, if it is to be controlled by electric light, it is dressed up, where as fire is uncontrollable and naked. Light is a comprehensible representation of the human mind, whereas flame is incomprehensible and hence difficult to represent. So the decision to use neon represents the possibility of mental control.*[6]
- ☐ Developments in science and engineering deeply influenced the work of artists exploring the potential of motion and light.
- ☐ The interdisciplinary science of cybernetics, which conceived of both animals and machines as systems of interconnected feedback loops, became a model for kinetic art that was responsive to its environment.
- ☐ Nicolas Schöffer's *CYSP I* (1956; Works, 62) was developed in collaboration with Dutch electronics corporation Philips. An 'electronic brain', sensors, controls and motors enabled the work to interact with its environment by physically responding to sound and movement. The viewer thus became an active participator in the experience of the work. — en.wikipedia.org-öffer
- ☐ Schöffer later incorporated these concepts into monumental architectural structures, including the *Spatiodynamic Tower* in Liège (1961), a fifty-two-metre tower that incorporated sixty-four revolving mirrors, seventy projectors, 120 coloured spotlights, five half-hour music recordings, along with a variety of sensors that enabled the computer-controlled structure to respond to its environment. — dada.compart-bre
- ☐ These early interactive works were important precursors to a broad range of contemporary practices involving robotics, responsive environments and intelligent architecture.
- ☐ Artists have used kinetics and light to explore parallels between electronic technology and natural energetic phenomena and to consider the relationship between creation and destruction.
- ☐ German- born artist Gustav Metzger published *Auto-Destructive Art*, thefirst of several related manifestos, including proposals for integrating art with science and technology and using cybernetics and computers to create self-

destructing civic monuments that would exist 'from a few minutes to twenty years.'

- ☐ in 1966, with a catalogue essay by French art historian Frank Popper, whose comprehensive book, *Origins and Development of Kinetic Art*, was published in French in 1967 and translated into English in 1968. Kinetic Art and light art not only became identified as movements, but motion and light transcended stylistic categories and were employed by artists around the world.
- ☐ Sharing an affinity with Wilfred's Clavilux and eighteenth and nineteenth century experiments with light organs, the desire to combine sound and image to create the experience of synaesthesia reached a culminating point in the mid-1960s, when it became popular fare at rock concerts.
- ☐ Of 1960s events, '9 evenings: theatre & engineering' generated the most excitement about the use of electronic media in art and has exerted the most enduring influence. Spearheaded by Klüver and Rauschenberg in October, 1966, this legendary series of technologically enhanced performances in New York City included work by ten artists, composers and choreographers associated with a variety of avant-garde practices ranging from Pop to Fluxus. Bell Labs engineers assisted the artists in realizing their performances.[7] '9 evenings' was the maiden voyage of the organization Experiments in Art and Technology (E.A.T.), which played a central role in promoting collaboration between artists and engineers.
- ☐ 1968 was a watershed year for electronic art involving motion, light and time, especially with respect to publications and exhibitions.
- ☐ 1968 was a watershed year for electronic art involving motion, light and time, especially with respect to publications and exhibitions. Jack Burnham published his seminal *Beyond Modern Sculpture: The Effects of Science and Technology on the Sculpture of Our Time*, which included chapters on automata, kineticism, light and robotics. Artist/scientist Frank Malina launched international publication of *Leonardo*, which remains the premier peer-reviewed journal for scholarship on the creative intersections of art and science. Hultén curated 'The Machine: As Seen at the End of the Mechanical Age' at the Museum of Modern Art in New York, which included ten artist- engineer collaborations, such as Jean Dupuy's *Heart Beats Dust*, part of a competition overseen by E.A.T. At the Brooklyn Museum of Art, the E.A.T. organized 'Some More Beginnings', an exhibition of over one hundred of the collaborative projects from the competition that could not be included in 'The Machine'. The Nelson Gallery in Kansas City organized 'Magic Theater', an exhibition that supported collaborations between artists and engineers.[8] Jasia Reichardt curated 'Cybernetic Serendipity', an internationally influential exhibition at the ICA in London, and the exhibition subsequently traveled to the Corcoran Gallery in Washington, DC and the Exploratorium in San Francisco. On the façade of the NAMA department store in Zagreb, Vladimir Bonacic installed his computerized light- installation, *DIN.21*, and the Gallery of Contemporary Art in Zagreb published the first issue of the journal, *Bit International*.
- ☐ By the 1970s, motion, light and time had become increasingly mainstream elements of artistic expression. Artists, drawing on a range of stylistic influences, have continued to explore their potential as the means and subject of their work. One of the most interesting developments over the last four decades has been the use of electronic media by artists to transform or translate between various forms of energy

- ☐ **Coded Form and Electronic Production (pg. 22)**
  - ☐ *Introduction:*
    - ☐ *Although it has been argued that technologically reproduced art lacks the aura of an individually handcrafted original, many uses of electronic technologies media to produce form algorithmically or by duplication conflate conventional notions of originality, creativity and objecthood, demanding a reconsideration of the definition of, and of art itself. Photocopying, for*

example, facilitated the rapid creation of endless variations, and the process of generating copious amounts of visual information became a primary goal. Computers have enabled artists to develop algorithms that generate n-dimensional representations and animations or to create multiple versions of three-dimensional forms using computer-aided design and rapid-prototyping. In this case, the original might equally be said to be the data-file, its visualization, or any of the 2D or 3D prints that give the work a concrete physical presence.

- ☐ *Works:*
  - ☐ *Ben LAPOSKY Oscillation #4, 1956 page 79*
    Charles CSURI and James SCHAFFER Hummingbird, 1967
    James WHITNEY Yantra, 1950–7 page 80
    Frieder NAKE 13/9/65 Nr. 5, 'Distribution of elementary signs', 1965 page 80
    Kenneth KNOWLTON and Leon HARMON Studies in Perception 1, 1966 page 81
    Stan VANDERBEEK and Kenneth KNOWLTON Poem Field No. 2: Life LIke, 1967 page 82 Jud YALKUT and Nam June PAIK Beatles Electroniques, 1966–9 page 83
    Bruno MUNARI Xerografie Originali, 1965 page 83
    SKB 'PROMETEI' (V. BUKATIN, B. GALEYEV, R. SAYFULLIN Electronic Painter, 1975–80
    Ralph HOCKING Complex Wave Forms, 1977 page 84
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    Lillian SCHWARTZ with Kenneth KNOWLTON Pixillation, 1970
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    Nancy BURSON First and Second Beauty Composites, 1982
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    Edmond COUCHOT with Michel BRET and Hélène TRAMUS, I Sow to the Four Winds, 1990 page 90
    Douglas GORDON 24-Hour Psycho, 1993 Mariko MORI Nirvana, 1996–7 page 92
    Michael REES Putto 2x2x4, 1998 page 93
    Ryoji IKEDA datamatics, 2006 page 93
    Adrian WARD Autoshop, 1999 page 94
    Robert LAZZARINI payphone, 2002 page 95
- ☐ *Documents:*
  - ☐ *Kenneth KNOWLTON Computer-animated movies, 1968 page 202*
    Robert MALLARY Computer Sculpture: Six Levels of Cybernetics, 1969 Herbert C. FRANKE Theoretical Foundations of Computer Art, 1971 page 205
    Marilyn McCRAY Introduction to 'Electroworks', 1979 page 206
    Sonia Landy SHERIDAN Generative Systems Versus Copy Art: A Clarification of Terms and Ideas, 1983
    Jud YALKUT The Alternative Video Generation, 1984 page 209
    Geoffrey BATCHEN Phantasm – Digital Imaging and The Death of Photography, 1994
    Michael REES Rapid Prototyping and Art, 1998 page 211
- ☐ *Review:*
  - ☐ An important precursor to digital computing debuted in France in 1801 – the Jacquard Loom, invented by Joseph-Marie Jacquard.
  - ☐ It employed wooden slats, encoded with instructions like computer punch-cards, to automate weaving of complex patterns.

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- ☐ British Industrialists supported by Prince Albert organized the Great Exhibition of 1851 in London at the Crystal Palace,an architectural and technological marvel designed by Joseph Paxton. Symbolizing the superior economic and technological strength of Great Britain, the displays intended to demonstrate to a rapidly growing urban middle class that mechanically manufactured goods met or exceeded the quality of handmade products, at a fraction of the price.
- ☐ Bauhaus designers in the 1920s, following the spirit of architect Walter Gropius's maxim ('Art and technology: a new unity!'), attempted to join the highest contemporary aesthetic values with industrial production in order to create stylish goods that were affordable to a wider public.
- ☐ The tension between handcrafted finery and machine-produced objects that arefinely designed persists with respect to electronic art.
- ☐ The long and diverse history of the mechanical production and reproduction of artworks includes using technological media, such as the camera obscura and photography to render convincing likenesses, various printing methods from wood-blocks to rapid-prototyping machines to output two- and three-dimensional multiples, and a range of algorithmic techniques to generate form from mathematical formulae, genetic algorithms and other coded relationships. These approaches to image production have affected the working processes of artists and transformed the end result and impact of their work on visual culture.
- ☐ Images were relatively scarce in private homes prior to the invention of the printing press. The advent of photography and the medium's popularity in the late nineteenth century provided the masses with convincing likenesses of loved ones, exotic destinations and other subjects that were far more affordable than portraits or scenes drawn or painted by hand. Images became daily fodder for mass audiences after the development of the rotary press around 1850 and improvements in the half-tone process in the 1890s, which enabled the cheap and rapid reproduction of photographs and drawings in newspapers.
- ☐ The flooding of daily life with objects and images is, therefore, a relatively recent occurrence in which technologies of production and reproduction have played a major role.
- ☐ In 'The Work of Art in the Age of Mechanical Reproduction' (1936), Walter Benjamin argued that technologically reproduced images lacked the 'aura' of an individually handcrafted original. At the same time, he recognized the potential of technological reproduction to enable the democratization of imagery, a condition that he hoped would offer a means of resisting Fascism and promoting democratic values.[9]
- ☐ In the wake of the individualistic bravura of Abstract Expressionism, by the late 1950s artists began to critically examine the distinctive, gestural signature that implied asymbolic connection between the hand of the artist and the surface of a canvas. Taking the ideological cluster of gesture, authenticity and originality as his foil, in the mid-1960s artist Roy Lichtenstein caricatured the abstract expressionistic brush-stroke in a cartoon style with a background comprised of Ben-Day dots – a printing technique used by newspapers to reproduce cartoons. Paradoxically, he initially mocked this eviscerated but iconic signifier in a series of unique paintings, only later reproducing them as serigraphs. Pushing this lineage further, Roman Verostko made the first robotic brush- strokes in 1987, using custom software and sumi brush mounted on a plotter to achieve remarkable gestural spontaneity from a series of algorithms.
- ☐ how concurrent developments in electronic art, such as Kriesche's, offered equally potent critiques of originality, authenticity, institutions and cultural hegemony. As Margot Lovejoy has pointed out, 'Electronic media challenge

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older [modernist] modes of representation. New media have created postmodern conditions and have changed the way art itself is viewed.'[11]

- ☐ Indeed, artists utilizing electronic tools to produce form by duplication, or by using algorithmic and other generative approaches, have challenged conventional notions of originality, creativity and art itself. Such artists recognized and exploited the potentials of electronic signal processing, computer graphics and electronic photocopying in the 1950s and 1960s and high-resolution digital photography, printing, video and rapid-prototyping since the 1980s.
- ☐ Important parallels and advances took place in music. Following the introduction of the electronic musical instruments,
- ☐ Electronic techniques for producing and reproducing sounds and images have affected the ways artists reflect on traditional aesthetic concerns and have expanded the creation and distribution of art, including its manifestations as code, as an image on a monitor and as an object.
- ☐ experimental art since the 1960s, particularly that involving electronic media, the conventional aesthetic privileging of precious objects has been increasingly supplanted by a more ephemeral aesthetics of information.[12]
- ☐ Given the long tradition of artists' use of technologies from wood-cut to off-set printing to mechanically reproduce works of art, it is not surprising that artists eagerly embraced electrostatic photocopying techniques (i.e. xerography) when the first commercial machine, the Haliod Xerox 914, was released in 1960.
- ☐ Taking a more conceptual approach, German artist Timm Ulrichs' *Die Photokopie der Photokopie der Photokopie* (1967) pushed the limits of these new machines while questioning conventional notions of the original versus the copy. Ulrichs photocopied an encyclopedia entry about photocopying, then copied the copy through ninety-nine successive generations, revealing the intrinsic qualities of the process. Was the original image degraded? Or was the whole process an original work of art, a parallel conversation or metadiscourse on electronic reproduction that embodied both a description and a demonstration of it? In any case, such work could not have been conceived or produced without electronic media, which were both the inspiration and means for the creation of innovative forms of expression.
- ☐ Some of the earliest electronically generated images include Ben Laposky's 'Oscillons', high-speed photographs of abstract patterns the American artist/mathematician first produced on an oscilloscope in 1950 by using a range of manually controlled, analogue devices. In the early 1950s, German artist/theorist Herbert Franke independently created electronic images using oscilloscopes as well. In 1953–4, fifty of Laposky's Oscillons were the subject of the exhibition 'Electronic Abstractions', another term Laposky used for his work, which opened at the Sanford Museum in Cherokee, Iowa and travelled to thirteen other venues across the US. In 1959, the exhibition 'Experimentale Asthetik', at the Museum of Applied Art in Vienna, displayed Oscillons and other early electronically generated images.
- ☐ Although Laposky and Franke did not employ digital computers in these early works, their use of algorithmic signals to programme and control imagery on an oscilloscope's cathode ray tube – an electronic screen similar to a TV monitor – was an important precursor to computer art.
- ☐ Much of the early development of computer graphics was undertaken by engineers and mathematicians. In 1961, electrical engineer Ivan Sutherland began doctoral research at
- ☐ MIT on the first interactive computer graphics system. In the process of creating the Sketchpad system, Sutherland also developed object-oriented programming, which revolutionized not only the field of computer graphics but the discipline of computer science in general. Bell Laboratories, in the

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suburbs of New York City, was a hotbed of computer graphics and electronic music development in the early 1960s, driven by staff researchers, often in collaboration with artists.[13] Stuttgart, Germany was the European centre of cutting-edge activity.

- ☐ At the University of Stuttgart, then called the Technische Hochschule, Ph.D. students Frieder Nake (Probability Theory, 1967; Works, 80) and Georg Nees (Philosophy, 1969) were deeply influenced by philosopher Max Bense, a co-founder with Abraham Moles of information aesthetics. Bense developed an influential theory of generative aesthetics that was the galvanizing force behind the so-called Stuttgart or Bense school of computer art and he coined the term 'artificial art' to refer to this new field.
- ☐ The first exhibitions of computer art took place in 1965: 'Generative Computergrafik', consisting of work by Nees at the Studiengalerie in Stuttgart (February 5–19); 'Computer Generated Pictures', featuring work by Noll and Bela Julesz at Howard Wise Gallery, New York (April 6–24); and 'Computergrafik', including work by Nake and Nees at the Galerie Wendelin Niedlich in Stuttgart (November 5–26).[14] German art students antagonized Nees's work, just as art critics dismissed the work shown in New York as 'cold and soulless' and having about as much appeal as the 'notch patterns found on IBM cards.'[15] Nonetheless, one work at Howard Wise Gallery, Noll's *Gaussian Quadratic* (1963), won the first computer art competition, sponsored by the journal *Computers and Automation*, in 1965, and Nake won in 1966 for his work employing random-number generators, *13/9/65 Nr. 5, Distributions of Elementary Signs* (1965).

- ☐ Although early computer graphics may have failed to enchant some art audiences, the philosophical, aesthetic and mathematical underpinnings of this work often were highly complex and shared much in common with other tendencies in contemporary art. Nake considered the computer a 'Universal Picture Generator', capable of producing all possible variations of a given combination of elements. Fellow German artist, Manfred Mohr, employed the mathematics of combinatorics programmed on a computer to derive and plot variations on a cube in his 'Cubic Limit' series (1972–76). A similarly systematic approach to art-making characterizes conceptual artist Sol LeWitt's manually produced *Incomplete Open Cubes* (1974), wherein variations on a cube are translated into a variety of media and scales, exemplifying the deployment of a single idea to become, in LeWitt's words, 'a machine that makes the art.' Such an algorithmic approach to image production was a catalyst for Casey Reas's *{Software Structures}* (2004) and John F. Simon Jr.'s *Every Icon* (1997). The latter consists of a personalized Java applet, available for purchase from Amazon.com for $20, that explores all 1.8×10^{308} possible permutations of black and white squares in a 32 x 32 grid, a task that will take hundreds of trillions of years to complete at a rate of 100 icons per second on a typical desktop computer from that era.

- ☐ Artists also used computers in order to create images that could not have been imagined or produced using traditional media.

- ☐ In addition to these algorithmic abstractions, computers have been employed to generate likenesses or emulate traditional works of art.I n addition to these algorithmic abstractions, computers have been employed to generate likenesses or emulate traditional works of art. Working together at Ohio State University, Charles Csuri and James Schaffer produced *Sine Wave Man* (1967) by coding selected coordinates from a line drawing of a portrait and subjecting them to mathematical modifications known as Fourier transforms. This work won the *Computers and Automation* annual competition in 1967 and was included in the exhibition 'Cybernetic Serendipity' (1968)

- ☐ In the lineage of early twentieth century experimental animators including Viking Eggeling, Hans Richter, Oskar Fischinger and Len Lye, the advent of computers led to the development of new methods for animation and filmmaking beginning in the 1960s.
- ☐ In the 1990s, advances in computer-aided 3D design software (CAD-3D) and rapid-prototyping technology (RP) have provided artists with tools to digitally encode and produce three-dimensional objects. RP can be thought of as three-dimensional printing. Although currently the process is neither as rapid nor as affordable as making a photocopy or printing out a page of computer-generated text, as art schools increasingly train students to use CAD-3D and as RP becomes cheaper and faster, one can anticipicate greater artistic experimentation with this medium.

- ⊟ **Charged Environments (p. 27)**
  - ☐ *Introduction:*
    - ☐ *In contrast to the simulations of virtual reality, responsive environments and contexts such as intelligent architecture and interactive installations tend not to create a representation that corresponds with physical reality but rather utilize real space in a way that renders it virtual and enables alternative, expanded forms of experience and reality awareness. Such works might employ sensors that respond to environmental conditions or the behaviour of inhabitants to reconfigure the physical environment. They may use closed circuit video to transform the audience into the subject of the work or may employ multimedia that enable collaborative exchanges both in physical proximity and remotely. High voltage electricity has been used as a primary artistic medium revealing the awe-inspiring power and spectacular beauty of this energy form. Performances in electronic environments can enable audience feedback to influence the unfolding of various elements or demonstrate the politicized contexts in which electronic media, particularly if mass media, operate.*
  - ☐ *Works:*
    - ☐ LE CORBUSIER, Iannis XENAKIS, Edgard VARÈSE Philips Pavilion, 1958 Carolee SCHNEEMANN with E.A.T. Snows, 1967 page 98

      John CAGE Imaginary Landscape No. 4 (1951), 1951 page 99

      PULSA Boston Public Gardens Demonstration, 1968 page 100 page 97

      Frank GILLETTE and Ira SCHNEIDER Wipe Cycle, 1968 page 100

      Robert RAUSCHENBERG with Billy KLÜVER Soundings, 1968 page 100

      Wolf VOSTELL and Peter SAAGE Electronic Dé-Coll/age Happening Room (Homage à Dürer), 1968 page 101

      Ted VICTORIA Solar Audio Window Transmission, 1969–70 page 102

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Les LEVINE Contact: A Cybernetic Sculpture, 1969 page 103
Peter CAMPUS Interface, 1972 page 104
Bruce NAUMAN Live-Taped Video Corridor, 1970 page 105
Peter WEIBEL Beobachtung der Beobachtung: Unbestimmtheit ('Observation of the Observation: Uncertainty'), 1973 page 106
Dan GRAHAM Present Continuous Past(s), 1974 page 106
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- ☐ *Documents:*
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- ⊟ *Review:*
  - ☑ Art has always been implicitly interactive, in the sense that it demands acts of perception and cognition on the part of the viewer. By emphasizing the durational aspect of perception and thereby making explicit the process of encountering works of art, artists began to challenge and alter traditional conceptions regarding the relationship between viewer and artwork. In *Art as Experience* (1934), philosopher John Dewey stressed the viewer's role in the production of meaning in art. Similarly, Marcel Duchamp stated in 1957 that, 'The creative act is not performed by the artist alone; the spectator brings the work in contact with the external world...and thus adds his contribution to the creative act.'[20]
  - ☐ As artists increasingly created kinetic works that reconfigured themselves or could be modified in response to the viewer's behaviour, traditional distinctions between viewing subject and art object, and between artist, artwork and audience, began to erode. No longer could the artist be considered the enigmatic creator of coded messages to be decoded by clever viewers. Semiotician Umberto Eco's theorization of the 'open work' in 1962 parallels the explorations of artists working with interactive media and audience participation, who increasingly came to think of themselves as offering audiences open-ended possibilities for the production of unpredictable meanings. Roy Ascott drew a striking parallel between participatory art and quantum physics, citing physicist J.A. Wheeler's contention that, 'To describe what has happened one has to cross out that old word "observer" and put in its place "participator". In some strange sense the universe is a participatory universe.'[21] Electronic media have made possible an extraordinary range of interactive potentials for observers to become active participators who navigate charged environments along a variety of possible trajectories.

  - ☐ This mid-century aesthetic shift took place internationally and involved artists associated with kinetic art, new tendency, Pop Art, Happenings, performance and other genres. In addition to participating in '9 evenings' and co-founding E.A.T., pop artist Robert Rauschenberg collaborated with Billy Klüver on several artworks, including *Soundings* (1967), an interactive electronic environment that responds to sound by activating spotlights that become increasingly luminous as the audience grows louder (see pages 2–3).

  - ☐ Some of the earliest electronic environments emerged from or overlapped with music, sound art and architecture. Perhaps the most spectacular of these was the *Poème Électronique*, created by architect Le Corbusier in collaboration with polymath Iannis Xenakis and composer Edgard Varèse for the Philips Pavilion at the 1958 World Fair in Brussels. This *gesamtkunstwerk*, or 'total work of art', integrated architecture, light, film and sound.[23]For Expo 67 in Montreal, the Czech pavilion featured the Kinautomat, a form of interactive cinema invented by Raduz Cincera. Told from two opposing points of view that were projected side by side, at certain moments of dramatic tension the audience was invited to decide in which direction the narrative path would unfold. The Pepsi Pavilion, engineered by E.A.T. for the 1970 World Fair in Osaka, incorporated a mirrored dome ceiling, fog-machines, electronic music, a programmable, four-colour krypton laser that generated patterns in response to sound, and a complex sound system that enabled one to regulate the movement of live sound throughout the space. The same year, Russian collective Dvizheniye ('Movement'), drawing on roots in Constructivism and performance, created their *Kinetic Artificial Environment* for an industrial exhibition in Moscow. Building on prior experiments with 'cybertheatre' theorized by founding member Lev Nusberg, this massive interactive installation filled 660 square metres (over 7000 square feet) with multimedia elements including light, sound and film that could be triggered by various sensors.[24]

- ☐ The 1970 exhibition, 'Software – Information Technology: Its New Meaning for Art', also incorporated architectural and sonic elements in electronic environments. Curated by art historian Jack Burnham for the Jewish Museum, it included 'SEEK', created by Nicholas Negroponte and the MIT Architecture Machine Group (1969–70; Works, 185) and Ted Victoria's *Solar Audio Window Installation* (1969–70; Works, 102). The former, a computer-controlled robotic environment, could, at least in theory, reconfigure itself in response to the behaviour of the gerbils that inhabited it. In Victoria's installation, solar panels powered ten radios, which were connected to contact speakers placed on the windows of the building, turning the Jewish Museum into a giant, faintly audible sound system and information outlet. Because the volume was no louder than a whisper and could be heard only by placing one's ear very close to or against a window, the audience was drawn to actively interact with the architectural body of the museum.

- ☐ The radio waves transmitting content to Victoria's installation are a form of electromagnetic radiation that, like television, satellite and microwave transmissions, were a driving force for artist Tom Sherman's *Faraday Cage* (1972) and Catherine Richard's *Curiosity Cabinet for the End of the Millennium* (1995; Works, 112). These habitats, like the original described by British physicist Michael Faraday in 1836, shield their inhabitants from the invisible assault of electromagnetic radiation, a growing concern given the proliferation of wireless devices. Conversely, the work of Joyce Hinterding (Works, 99) and of Radioqualia has employed VLF (Very Low Frequency) receivers to capture and sonify cosmic energy, allowing us to hear sounds generated billions of years ago in distant galaxies.

  Such work builds on the ideas of American composer John Cage, who

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emphasized the importance of focused listening to the ambient sounds of one's environment. Indeed, it is hard to overestimate Cage's contribution to electronic art. Not only did he employ electronics for composition and in performance, but his aesthetic theories advocated their use to support aleatory (chance) methods, indeterminacy and mutability and to emphasize the unique sonic features of found objects and environments. In the tradition of Italian futurist Luigi Russolo's 1913 manifesto 'Art of Noises', Cage wrote in 1937 that, 'the use of noise to make music will continue and increase until we reach a music produced through the aid of electrical instruments which will make available for musical purposes any and all sounds that can be heard'.[25]

In 1939, Cage composed his first work to use electronic media, *Imaginary Landscape No. 1* (Works, 99), one of five 'imaginary landscapes' composed between 1939–52. In this piece, dampened piano and cymbal were performed along with multiple phonographs that played Radio Corporation of America (RCA) pure electronic test-tones. *Imaginary Landscape No. 4* (1951) was scored for twelve radios, each controlled by two performers. Changes in tuning frequency, amplitude and tone of each radio throughout the composition were determined by chance, drawing on the tradition of Dada artists, who had been inspired by Stéphane Mallarmé's 1897 poem, '*Un coup de des jamais n'abolira le hazard*' ('A throw of the dice will never abolish chance'). To establish values for variable parameters, Cage consulted the I Ching, an ancient Chinese system of knowledge, wherein prophecy is accessed by casting coins or yarrow-stalks. The piece created an unpredictable pastoral of sounds, culled from the ethereal environment of the airwaves and reproduced on the most common of consumer electronic devices. Drawing on Dada traditions of employing found objects as artistic media, Cage's use of radios conflates electronic devices designed to reproduce sound with acoustic devices designed to produce music. Similarly, the use of sound carried by a given radio frequency as sonic content conflates remotely transmitted sound, static (between stations), and the immediacy of live music performance.

- ☐ Growing out of his enigmatic *4'33"* (1952), a piano composition that had no notes but invoked the ambient sounds of the environment as its sonic content, Cage's *Variations VII* (1966), engineered by Cecil Coker for E.A.T.'s '9 evenings', used as sound sources, 'only those sounds which are in the air at the moment of performance, picked up via the communication bands, telephone lines, microphones...' The performers revealed these ambient sounds by processing them with 'a variety of household appliances and frequency generators'.[26] Cage's publications and his lectures at the New School, New York, influenced numerous visual artists, whose work impacted the history of electronic art by experimenting with audience participation and interactivity, thus challenging traditional boundaries between artist, artwork and audience. These include Allan Kaprow, who staged his first happening in 1956; George Brecht and Yoko Ono, members of Fluxus, whose event-scores of the late 1950s anticipated conceptual art; and Nam June Paik, a pioneer of video, robotics and other electronic media.

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- ☐ Paik's early electronic environments include his landmark 1963 exhibition, *Exposition of Music-Electronic Television* at the Galerie Parnass in Wuppertal, Germany. Inspired by Cage's technique of composing for 'prepared piano' (modified by inserting objects, such as nuts, bolts or pieces of rubber, lodged between and entwined around the strings in order to alter its sound),
- ☐ Cybernetics, information theory and the circularity of feedback inherent in closed-loop video were at the theoretical and formal core of many important early interactive, electronic environments in the 1960s and 1970s. In *Expanded Cinema* (1970), Gene Youngblood documented the challenges posed by early interactive video installations to the uni-directionality of commercial media, providing a context for two-way creative exchanges. Art historian Inke Arnes has described such 're- use' of broadcast media in situationist terms, as a form of détournement, in which the (mis)appropriation and repurposing of conventions produce shifts in social consciousness.[27]long these lines, in works like *Iris* (1968) and *Contact: A Cybernetic Sculpture* (1969; Works, 103) by Levine, and *Wipe Cycle* (1969; Works, 100) by Gillette and Schneider, video cameras captured various images of viewers, which were fed back, often with time-delays or other distortions, onto a bank of monitors. As Levine noted, Iris 'turns the viewer into information... *Contact* is a system that synthesizes man with his technology... the people are the software'.[28] Schneider amplified this view of interactive video installation, stating that, 'The most important function... was to integrate the audience into the information'.[29] Gillette described how *Wipe Cycle* was related to satellite communications: 'you're as much a piece of information as tomorrow morning's headlines – as a viewer you take a satellite relationship to the information. And the satellite which is you is incorporated into the thing which is
- ☐ Bruce Nauman, who was sceptical of participatory art, approached closed-loop video literally from a different angle, with a no less jarring effect. His *Live Taped Video Corridor* (1970; Works, 105) presciently suggested a more haunting and increasingly ubiquitous aspect of this technology: surveillance. In this installation, one walks down a claustrophobically narrow corridor towards two stacked video monitors, the bottom of which displays one's video image (captured in realtime from the rear) growing progressively smaller. As Dörte Zbikowski has noted, 'the feeling of alienation induced by walking away from yourself is heightened by your being enclosed in a narrow corridor. Here, rational orientation and emotional insecurity clash with each other. A person thus monitored suddenly slips into the role of someone monitoring their ... own activities'.[31] Similarly, Peter Weibel's *Observation of the Observation: Uncertainty* (1973; Works, 106), incorporates juxtapositions of three video cameras and monitors such that viewers cannot see themselves from the front – the angle from which one typically sees oneself. This perceptual prison restricts self-observation to the oblique angles from which one is typically seen only by others.
- ☐ Building on the sort of aesthetic experiences, both interactive and self-contained, enabled by closed-circuit video and other media, artists have used

emerging and evolving technologies to explore a wide range of electronic environments.

- ☐ Electricity has been used by artists as a medium in and of itself to create highly charged experiences as well as more subtle meditations on the electrical foundations of life.

- ☐ **Networks, Surveillance, Culture Jamming (p. 32)**
  - ☐ *Introduction:*
    - ☐ *The exchange, transfer and collaborative creation of information has a long history in art prior to the advent of telecommunications. Public access cable, satellite transmissions and computer networking vastly expanded these capabilities. Building on the traditions of mail art, fax art and video, artists have used these technologies to create contexts for the decentralized, collaborative and distributed production of meaning. By commandeering the technologies of surveillance and control, they draw attention to the encroachment of privacy by corporations and governments. Through telematic culture-jamming, their agit prop appropriations and interventions confound traditional structures of value, legitimacy and power.*
  - ☐ *Works:*
    - ☐ *Marta MINUJIN Circuit Super Heterodyne, 1967 page 120*
      Hans HAACKE News, 1969 page 121
      Douglas DAVIS Electronic Hokkadim, 1971 page 122
      Franklin Street Arts Center, Center for New Art Activities, Art-Com/La Mamelle (Liza BEAR , Keith SONNIER, Willoughby SHARP, Duff SCHWENIGER, Sharon GRACE, Carl LOEFFLER in collaboration with NASA and the Public Interest Satellite Association (PISA) Send/Receive Satellite Network, 1977 page 123
      Robert ADRIAN The World in 24 Hours/Die Welt in 24 Stunden, 1982 page 124
      Mario RAMIRO with Jose W. GARCIA Clones: A Simultaneous Radio, Television and Videotex Network, 1983 page 125
      Roy ASCOTT, La Plissure du Texte, 1983 page 125
      Steve MANN WearComp, 1970s-present page 126
      Norman WHITE and Doug BACK Telephonic Arm Wrestling, 1986 page 126
      Julia SCHER Security by Julia, 1989–90 page 127
      Paul SERMON Telematic Dreaming, 1992 page 128
      VAN GOGH TV/PONTON EUROPEAN MEDIA ARTS LAB Piazza Virtuale ('Virtual Square'), 1993
      Antonio MUNTADAS The File Room 1994 page 129
      Jane PROPHET (with Gordon SELLEY) TechnoSphere, 1995 page 130
      I/O/D (Matthew FULLER, Simon POPE, Colin GREEN) I/O/D 4: The Web Stalker, 1997 pages 131
      NECRO ENEMA AMALGAMATED (Eric SWENSON and Keith SEWARD) BLAM! 1993 page 132
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      ®TMARK and THE YES MEN GATT.org and WTO imposter performances, 1999–2002 page 133

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Johannes GEES and CALC (Tomi SCHEIDERBAUER, Teresa ALONSO, Luks BRUNNER, Malex SPIEGEL, Roger LUECHINGER) Communimage, 1999 page 134
Talan MEMMOTT Lexia to Perplexia, 2000 page 135
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- ☐ *Documents:*
  - ☐ *Bertolt BRECHT The Radio as an Apparatus of Communication, 1932 page 226*
    Willoughby SHARP Worldpool: A Call for Global Community Communications, 1978 page 227
    Peter D'AGOSTINO Proposal for QUBE, 1980 page 228
    Roy ASCOTT Art and Telematics: Towards a Network Consciousness, 1984 page 229
    Nam June PAIK Art and Satellite, 1984 page 231
    Eduardo KAC Telepresence Art, 1993 page 232
    Robert ADRIAN Art and Telecommunications 1979–1986: The Pioneer Years, 1995 page 237
    Rafael LOZANO-HEMMER Perverting Technological Correctness, 1996 page 238
    Natalie BOOKCHIN, Alexei SHULGIN Introduction to net.art, 1994–99 page 238
    Niranjan RAJAH Nation, National Culture and Art in an Era of Globalization and Computer Mediated Communications, 2000 page 239
    Maria FERNANDEZ Is Cyberfeminism Colorblind?, 2002 page 241
    Steve MANN The Post-Cyborg Path to Deconism, 2003 page 242
- ☐ *Review:*
  - ☐ The growing interest in creating interactive contexts for aesthetic encounters dovetailed with the increasing predominance of electronic telecommunications, particularly radio and television, as arbiters of contemporary cultural and values. This, of course, made such media an important locus of critical artistic exploration. The theoretical roots of artists' use of telecommunications for bi-directional exchanges may be traced to German dramaturge Bertolt Brecht's manifesto, 'The Radio as an Apparatus of Communication' (1932; Documents, 226), which has offered ongoing inspiration to artists working with a wide range of interactive media.[32] As artist Peter D'Agostino has noted, Brecht sought to change radio 'from its sole function as a distribution medium to a vehicle of communication [with] two-way send/receive capability...'[33] Brecht's essay proposed that media should: *[L]et the listener speak as well as hear ... bring him into a relationship instead of isolating him. On this principle the radio should step out of the supply business and organize its listeners as suppliers... [I]t must follow the prime objective of turning the audience not only into pupils but into teachers. It is the radio's formal task to give these educational operations an interesting turn, i.e. to ensure that these interests interest people. Such an attempt by the radio to put its instruction into an artistic*

form would link up with the efforts of modern artists to give art an instructive character.[34]

Indeed, many artistic experiments with television, video and other mass media have been motivated by a Brechtian desire to wrest the power of representation from the control of corporate media and make it available to the public. In the mid-1970s, Douglas Davis noted that, 'Brecht... pointed out that the decision to manufacture radio sets as receivers only was a political decision, not an economic one. The same is true of television; it is a conscious (and subconscious) decision that renders it one-way...'[35] Taking advantage of thirty minutes of free network broadcast time on WTOP-TV in Washington, D.C., Davis's *Electronic Hokkadim* (1971; Works, 122) was billed by the artist as the 'world's first participative telecast.'[36]

Viewers called the station via telephone and the wave patterns of their voices, routed to Paik-Abe and Eric Siegel video synthesizers, affected the movement of video images on screen. As David Ross wrote in 1974, this work, 'linked symbiotically with its viewers whose telephoned chants, songs and comments reversed through the set, changing and shaping images in the process.'[37] Davis later commented that,

My attempt was and is to inject two-way metaphors – via live telecasts – into our thinking process. All the early two-way telecasts were structural invasions... I hope [to] make a two-way telecast function on the deepest level of communication ... sending and receiving... over a network that is common property.[38]

Davis's work exemplifies the long and distinguished history of artistic attempts to democratize media by enabling users to participate as 'content-providers,' rather than as passive consumers of pre-fabricated entertainments and commercial messages.

- ☐ Another early artistic attempt at multidirectional exchange took place on 30 July, 1971, when E.A.T. organized *Utopia Q&A*, an international telecommunications project that joined participants in New York, Tokyo, Ahmedabad and Stockholm. Telex enabled the exchange of texts between the remote sites via specialized local terminals that printed out incoming information. Participants from around the world posed questions and offered prospective answers regarding changes that they anticipated occurring over the next decade. As Billy Klüver observed in one of the early communications posted during the event: *Our hope is that this project will contribute to recognition of and contact between different cultures. We have chosen a medium which was invented in 1846 which is essentially mechanical and which was not developed since the late nineteenth century. Like print, its very simplicity provides access. We believe that this is the first worldwide people-to-people project, imagining their future.*[3]9

Utopia Q&A poignantly utilized telecommunications to enable an interactive exchange across geopolitical borders and time-zones, creating a global village of ideas about the future.

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The prohibitive cost and inaccessibility of satellite links and computer-networking imposed severe limits on the creative potential of telecommunications media for artists in the late 1970s and early 1980s. Through tremendous resourcefulness, expansive personal networks and, at times, great personal expense, the pioneers of telecommunications art prevailed in their exploration of this medium. Given the proliferation of the Internet in the 1990s, it is now hard to imagine how difficult and expensive it was for artists to get online. Lobbying bygrass-roots community organizations enabled limited public access to satellite communications

- ☐ The first transcontinental, two-way satellite broadcast, *Send/Receive Satellite Network* (1977; Works, 123), sometimes referred to as *Two-Way Demo*, involved an alliance between the Center for New Art Activities and the Franklin Street Arts Center in New York, Art Com/La Mamelle Inc. in San Franciscoand NASA, with assistance from the Public Interest Satellite Association. Collaboration was a key aspect of the work, which was spearheaded by several artists affiliated with the artists' collective, Collaborative Projects, also known as Colab. Conceived by Keith Sonnier, Liza Bear served as project manager and Willoughby Sharp and Duff Schweninger rigged a military infrared transmission system between the mobile satellite transceiver (affectionately known as the 'Bread Truck') at the Battery Park landfill and the Manhattan Cable system downlink at the Rector Street subway station. Artists Sharon Grace and Carl Loeffler coordinated the San Francisco end, gaining access to a fully equipped studio. For six hours over a period of two days, participants on both coasts engaged in a two-way interactive satellite transmission, which was edited and displayed in a split-screen format that was distributed live within the respective cities via cable television. An estimated audience of 25,000 watched bi-coastal dance improvisations and music performances along with discussions on the impact of new technologies on art.

- ☐ As an outgrowth of their 'Aesthetic Research in Telecommunications' projects begun in 1975, Kit Galloway and Sherrie Rabinowitz organized the *Satellite Arts Project: A Space with No Boundaries* (1977). With the support of NASA, the artists produced an interactive dance concert between geographically disparate performers, two in Maryland and two in California. Composite images enabled the dancers to coordinate their movements, mindful of latency (time-delay), with those of their local and remote partners. In 1980, Galloway and Rabinowitz organized *Hole in Space*, a satellite project that connected two storefronts in New York and Los Angeles. The artists purposely displaced the work from an art context and set it into the flux of everyday life, where it became activated when people happened upon it by chance. As Hank Bull noted of the video documenting the piece, 'The results were astounding and often very moving... People sang songs together, played games, even made contact with long lost relatives.'[40]

- ☐ Perhaps the first artistic application of computer networking took place in the Sat-Tel-Comp Collaboratory (1978). This event was organized by the Direct

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Media Association, an artists' group formed by Canadian artist Bill Bartlett in British Columbia. Bartlett gained access to the I. P. Sharp Associates (IPSA) international computer-timesharing network through Toronto-based artist Norman White, who had befriended IPSA programmer Bob Bernecky and received a free account. The Collaboratory used this precursor to Internet- based email to exchange texts between four sites in the US and Canada. It also used telephone lines for the transmission of slo-scan video images at a rate of one frame every eight seconds between the Open Space Gallery in Victoria, British Columbia and nine sites in Canada and the US.

- ☐ Within a few years artists all over the world were using computer-networking as a bona-fide artistic medium, dubbed 'telematic art' by Roy Ascott in 1983. Robert Adrian played an important role in enabling artists to explore the medium's unique creative and expressive potentials by helping develop a free system sponsored by IPSA, known first as ARTBOX and later as ARTEX (Artist's Electronic Exchange.) Adrian was also a pioneering practitioner, whose most ambitious early work, *The World in 24 Hours* (1981; Works, 124) won the Golden Nica prize at Ars Electronica. This project used ARTBOX to connect sixteen cities on three continents, creating a global network of artists and artist groups, each of which organized a contribution that made use of any combination of slo-scan, fax, telephone and computer-conferencing to exchange and create sounds, texts and images.

Identified by *Leonardo* editor Roger Malina as an unsurpassed landmark in the history of telematic art, Ascott's *La Plissure du Texte* ('The Pleating of the Text', 1983; Works, 125) used ARTEX to explore the potential of computer networking for the interactive, collective creation or 'distributed authorship' of an artwork by remote participators. Collaborators at eleven locations in the US, Canada, Europe and Australia each represented a character, such as Witch, Sorcerer or Princess and participated in producing and contributing texts and ASCII images to the emerging 'planetary fairytale'. Ascott had envisioned remote artistic collaboration via computer networking in 1966 and organized his first such project, *Terminal Art*, in 1980. He claimed that the collective, process-oriented and emergent characteristics of distributed authorship in telematic artworks challenges the conventional categories of artist, artwork and viewer and the opposition of subject and object. Aspects of traditional narrative structure may remain, while others are relinquished in order to allow a more open-ended development, fashioned by participators involved in a multi-directional creative exchange. Unlike satellite, which demands that interaction be synchronized in real-time, computer networking is asynchronous, a quality Ascott embraced for its ability to enable exchanges that metaphorically punch holes through both space and time. Following Pierre Teilhard de Chardin's concept of the noosphere and Peter Russell's notion of the global brain, Ascott's theoretical essays such as 'Art and Telematics: Towards a Network Consciousness' (1984, see Documents, page 229) and *'Is There Love in the Telematic Embrace?'* (1990) posited that telematic art enables an expanded, planetary consciousness that is greater than the sum of its parts.

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- ☐ The potential of telecommunications to allow individual and cultural freedom was at the heart of the major satellite telecast that Nam June Paik organized on New Year's Day, 1984.
- ☐ Eduardo Kac has extended telematic interaction to plants and animals. *Essay Concerning Human Understanding* (1994), created in collaboration with artist Ikuo Nakamura, facilitates remote communication between a canary in Kentucky and a philodendron plant in New York. As Kac explained,

  An electrode was placed on the plant's leaf to sense its response to the singing of the bird. The voltage fluctuation of the plant was monitored through a [computer] running software called Interactive Brain-Wave analyzer. This information was fed into another [computer]... which controlled a MIDI sequencer. The electronic sounds [sent from the plant to the bird] were pre- recorded, but the order and the duration were determined in real time by the plant's response to the singing of the bird.[42]

  Although the piece focused on communication between the bird and plant, Kac noted that humans interacted with the bird and the plant as well, causing the bird to sing more or less, and the plant to activate a greater or lesser number of sounds. In this way, humans, plants and animals became part of a cybernetic system of inter-related feedback loops, each affecting the behaviour of the other and the system as a whole.

- ☐ ...the first artwork to join telematics and robotics, a research field known as telerobotics, was *Telephonic Arm Wrestling* (1986; Works, 126) by Norman White and Doug Back.
- ☐ Artist/engineer Ken Goldberg, working with a team of collaborators in the robotics lab at UC Berkeley, created *Tele-Garden* (1995). This work used a Web-based interface to enable remote participants from around the world to become part of a virtual community that collectively controlled a robotic device to seed and maintain a living garden.
- ☐ In contrast to the idealism that characterizes these telematic and telerobotic works, electronic media have also been used to interrogate and actively fight censorship, corporate hegemony, pollution, gender discrimination and the proliferation of surveillance and control systems that threaten civil liberties. Concerned about the potential of technology both to support and resist censorship, *The File Room*, created by artist Antonio Muntadas with the collaboration of Paul Brenner and Maria Roussos in 1994 (Works, 129), is one the most provocative and enduring early works of Web-based art. It was conceived as an open-ended project comprised of a massive and expanding electronic database on the censorship of art. Utilizing the hyperlinking capacity of the Web, it provides a wealth of incisive information on the subject. In addition, users may contribute their own experiences of censorship, enabling the work to grow as a collaboration involving a global community of participators.
- ☐ Also approaching the Web as an artistic means of resistance, the collaborative ®TMark (pronounced artmark) serves as an activist consulting firm that uses subversive tactics to help artists fight hostile corporations, particularly with

regard to issues of intellectual property. Two successful campaigns during 1999–2000 include defending the European artist-group eToy from a court injunction filed by Internet toy vendor eToys over rights to the domain eToy.com and defending the journal *Leonardo* from a law-suit filed by Leonardo Finance, which was disgruntled because search engines returned the magazine higher in their rankings than the French financier. ®TMark's culture jamming strategies against the eToys corporation resulted in a dramatic reduction of its stock-price and the case was dropped. The *Leonardo* strategy produced a plethora of protest Websites, creating an even more competitive environment for search-engine results for Leonardo Finance, whose suit was dismissed by the court.

- ☐ The relationship between industry and environmental pollution was made clear in Hans Haacke's *Rhine Water Purification Plant* (1972), which demonstrated how the river flowing through Krefeld, Germany, had been used as a repository for raw waste.ver three decades later, former US Vice-President Al Gore's influential film, *An Inconvenient Truth* (2006), helped raise popular awareness of the potentially catastrophic effects of carbon dioxide (CO2), which has been linked to the destruction of the ozone layer and global warming. An increasing number of contemporary artists,including Tiffany Holmes, Natalie Jeremijenko, Andrea Polli and Amy Youngs, are using electronic media to create artworks that explore questions of air, water and noise pollution and to employ art and design as a strategic tool for creating awareness and promoting conservation. For example, Beatriz DaCosta's *Pigeon Blog* (2006) used miniature air pollution sensors, GPS units, and transmitters attached to homing pigeons to evaluate and map local air quality, making that data available through the project Website. Michael Mandiberg's *Real Costs* (2007) is a Firefox browser plug-in that inserts CO2 emissions information into search results for flights from commercial travel Websites, such as Orbitz.com. When researching airfares, the user retrieves not only the price in dollars but comparative data for carbon emissions for the journey by plane, car, bus and train, the number of tree-years required to offset the pollution and the annual per capita carbon emissions by country.
- ☐ Electronic media also have been used extensively by artists to reveal attitudes and prejudices pertaining to gender. Cornelia Sollfrank's *Female Extension* (1997) is a legendary cyberfeminist art-hack. In response to the call for contributions for the net art exhibition 'Extensions', organized by the Gallery of Contemporary Art at the Hamburg Art Museum, she fabricated over 200 female alter-egos from seven countries and developed a software program that generated individual artworks for each of them. Delighted by the large number and diversity of contributions, the museum issued a press release noting that of the over 280 applications, two-thirds were from women. Despite the high proportion of ostensibly female submissions, the three top prizes were awarded to men and the jury failed to catch on to what the artist described as 'the apparently meaningless flood of data' produced by her 'automatically generated net art.'[44]
- ☐ Jodi.org, initially launched by artists Joan Heemskerk and Dirk Paesmans (Jo + Di) around 1995, is a Web-based artwork that uses the medium's vernacular as its content in a similarly critical manner.

- ☐ The issue of surveillance that was raised in Nauman's *Live Taped Video Corridor* and reinforced in Steina's *All-Vision* was made more explicit in Robert Adrian's *Surveillance I* (1979), in which the artist produced a videotape of himself captured on surveillance cameras as he walked through the Karlsplatz subway station in Vienna. Inspired by the situationist theory of détournement, since 1996, the New York Surveillance Camera Players have been enacting agit-prop theatre performances, based on sources including George Orwell's *1984* (1949) and Wilhelm Reich's *The Mass Psychology of Fascism* (1933), in front of publicly installed surveillance cameras.
- ☐ GPS technology and other forms of locative media have provided tools for artists to generate alternative forms of geography and mapping and to invent novel modes of awareness, interaction and exchange.
- ☐ ...mobile locative devices become increasingly powerful, flexible, and ubiquitous, one can expect a proliferation of such work and the integration of its ideas into popular culture.

- ⊟ **Bodies, Surrogates and Emergent Systems (p. 38)**
  - ☑ *Introduction:*
    - ☑ *Drawing on information theory, the interdisciplinary field of cybernetics drew striking parallels between the systemic processing of information in humans and machines, contributing greatly to the fields of artificial intelligence, robotics, and, subsequently, artificial life. Artists have joined their bodies, and their audiences, with electronic media or created robots and other forms of surrogate beings in order to examine the cyborgian nature of human existence and to ponder what a post-human existence might be. Others have used genetic algorithms or viral behaviour to create and study self-organizing systems that possess many qualities of life itself, including the replication and dissemination of information and survival and reproduction in competitive environments. In many cases, artists have attempted to bridge the apparent divide between carbon-based organisms and silicon forms of intelligence and life, between the real and the artificial, suggesting that these distinctions and social conventions are becoming increasingly blurred.*
  - ☐ *Works:*
    - ☐ Atsuko TANAKA Electric Dress, 1956 page 140

      Edward IHNATOWICZ The Senster, 1969–71 page 141

      Mark BOYLE and Joan HILLS Son et Lumière for Bodily Fluids and Functions, 1966

      Thomas SHANNON Squat, 1968

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- ☐ *Documents:*
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- ☐ *Review:*

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- ☐ Myth and legend abound with tales of artists, spiritualists, and scientists imbuing base matter with the qualities of living beings, including vitality, intelligence, development and reproduction.In Ovid's *Metamorphoses*, the artist-king Pygmalion, aided by Aphrodite, brought to life a marble sculpture of a woman, known as Galatea. In the sixteenth century legend of the golem, a lump of clay was brought to life by breathing a form of God's name into it. In Shelley's pre- Victorian techno-thriller, electricity is the animating force that brings matter to life.
- ☐ In the 1960s, Jack Burnham prophesied that, 'As the Cybernetic art of this generation grows more intelligent and sensitive, the Greek obsession with "living" sculpture will take on an undreamed reality.'[48] Concerning the cultural and social implications of the growing field of robotic art in the 1990s, artist Eduardo Kac noted that,

  If artists working with or interested in robotics cannot ignore mythological, literary or industrial definitions of robots … , it is also true that these definitions do not directly apply to any given robotic artwork … As artists continue to push the very limits of art … they introduce robotics as a new medium at the same time that they challenge our understanding of robots – questioning therefore our premises in conceiving, building, and employing these electronic creatures.[49]

  Indeed, some contemporary artists have joined their own bodies (and/or those of their audiences) with electronic media and created robots and other forms of surrogate beings in order to examine the cyborgian aspects of human existence and to ponder what a post-human existence might comprise. Others have used genetic algorithms or viral behaviour to create and study self-organizing systems that possess many qualities of life itself, such as the replication and dissemination of information, or survival and reproduction in competitive environments. In many cases, artists have attempted to bridge the apparent divide between carbon-based organisms and silicon forms of intelligence and life, between the real and the artificial, suggesting that these distinctions are becoming increasingly blurry and permeable.
- ☐ Contributing to this ongoing dream of endowing base- matter with the qualities of life,
- ☐ Also pushing the boundaries between organic and electronic bodies, Edward Ihnatowicz's *Senster*, (1969–70; Works, 141) was an interactive sculpture modelled on biological systems, in this case a lobster-claw. Like the artist's earlier *Sound Activated Mobile* (*SAM*, 1968), it responded smoothly and gracefully to the presence of the audience, simultaneously delighting and frightening those who encountered it and were encountered by it. Taking a different but equally organic approach to robotic art, Thomas Shannon's *Squat* (1966; Works, 142), was connected to an ivy plant. When the plant was touched, the changes in its electronic potential triggered motors that caused the sculpture to respond to the presence of viewers. Inspired by the notion that plants can respond to human emotions (a hypothesis known as the Backster Effect), in the early 1970s architect John Lifton attached electrodes to a plant, the output voltages of which drove a sound synthesizer. Guided by different principles though applying related techniques, Christa Sommerer

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and Laurent Mignonneau's *Interactive Plant Growing* (1993) incorporates real plants as an interface that, when touched by viewers, generates the growth of A-Life plants projected on a screen. Amy Youngs' *Rearming the Spineless Opuntia* (1999) combines sensors and a robotic, thorned shield that protects a genetically engineered, spineless cactus when would-be predators enter its vicinity. In *Experiments in Galvanism* (2003), Garnet Hertz implanted a Web-server in a preserved frog, the legs of which twitch when electrically stimulated via the Internet. Revelling in the jouissance of cause and effect, Hertz reflects light-heartedly on scientist Luigi Galvani's late eighteenth century experiments with electrophysiology that inspired Shelley's conception of Frankenstein, updating them with microelectronics and telerobotics. And in yet another take on joining organic and electronic media, in Adam Zaretsky's *MMMM* (*Micro Macro Music Massage*, 2001), sounds made by participants lounging in massage chairs altered the vibrational energy in each other's seats as well as in plate speakers underneath flasks of phosphorescent E. coli, causing the transgenic organisms to 'bounce, splash, stretch, bear-down and/or jump to attention in response to the audio source.'[50]

- ☐ In Dick Raaijmakers' *Graphic Method Bicycle* (1979), a nude performer astride a bicycle was wired to sensors that transformed his breathing, pulse, perspiration and muscle contractions into sound during an excruciatingly slow and physically demanding ten metre performance. More than any other artist, Stelarc has challenged the physical limits of the human body with respect to technology. Perhaps best-known for his controversial suspension performances, begun in 1976, in which he suspends his body (which he invariably refers to as 'the body') by cables attached to meat-hooks inserted in his flesh, Stelarc has used electronic media in his artwork since the mid-1970s. Indeed, these two aspects of his practice are integrally related to his theories on the body's obsolescence. As in Hershman's work, the performative body and the cyborgian body are continuous in Stelarc's oeuvre. In some of his performances, such as *Evolution* (1983), which employs the *Third Hand* (1981), the artist retains full control of robotic devices, activated by EMG signals of his abdominal and leg muscles. By contrast, in *Ping Body* (first performed in Sydney, 1996; Works, 154), Stelarc subjected his body to the control of the more or less random ebb and flow of amorphous data on the Internet, which triggered involuntary physiological responses, causing his arms and legs to jerk in a mysterious and disturbing dance.

- ☐ The complex layers of control and authority with respect to the cyborgian body and electronic systems were explored in *Epizoo* (1995; Works, 153) by Spanish artist Marcel.lí Antúnez Roca. In the tradition of Yoko Ono's *Cut Piece* (1966) and Marina Abramovic's *Rhythm 0* (1974), the artist submitted his body to the whims of the audience. By activating motorized devices, viewers manipulated Roca's nose, mouth, ears, glutea and pectoral muscles, causing bizarre contortions. Like the unwitting subjects in psychologist Stanley Milgram's 1974 study 'Obedience to Authority: An Experimental View' (sixty- five percent of those tested agreed to mete out the maximum punishment of 450 volts, several ticks beyond the indication, 'DANGER: SEVERE SHOCK'), so the audience of *Epizoo* was confronted with taking responsibility for its actions and the effects they caused on the performer, who was at their mercy.

- ☐ Following the inquiries of Gustav Metzger and Jean Tinguely into the relationship between the body, technology and destruction in art, Survival Research Laboratory (SRL), founded in 1978, makes robotic artworks that reveal the devastating power of technology. SRL's *Increasing the Latent Period in a System of Remote Destructibility* (1997), models a prospective future when robots act autonomously, communicating with other robots and machines to unleash destructive force on human and non-human targets. Just as Stelarc and Roca reverse the master-slave relationship between human and machine, so SRL's work explicitly enacts the potential dangers of surrogate agents rather than celebrating the utopian ideal of technologically mediated agency.
- ☐ On the more intellectual end of the spectrum of robot-to- robot interaction, in Ken Feingold's *If/Then* (2001), two talking robotic heads are nestled in packing peanuts in a cardboard shipping box. Complete with voice-synthesizers and motors that synchronize their mouth movements, they engage in a spoken philosophical discussion on the meaning of life. Drawing on natural language artificial intelligence research, such as ELIZA, Joseph Weizenbaum's famous 1966 computer program that emulated a psychotherapist, the conversation between the two bots is internally coherent but also very limited. Though human observers have found aspects of these robotic exchanges to be profound and humorous, the existential conversation could go on infinitely without anything of lasting value being communicated between the robots. Even if it did, how would anyone know? Feingold's updated Galateas ironically propose a future in which angst-ridden machine intelligences will wax poetic about their silicon navel lint.

- ☐ Expanding the bot-to-bot dialog, David Rokeby's *n-Cha(n)t* (2001) creates a community of artificially intelligent bots that communicate with each other. Developed at the Banff New Media Institute, the bots in this 2002 Prix Ars Electronica winner share the complex linguistic database generated by the artist's ongoing work, *The Giver of Names* (1991). They are programmed to engage in an internally coherent conversation, ultimately converging on a common 'chant' when they are part of a closed-system, unperturbed by external stimuli. But each of the bots is connected to a microphone that opens the system to interaction with human participants. A video image of a person's ear, displayed on each of several monitors, visually represents the current state of each artificially intelligent bot: receptive to the spoken input from a viewer, concentrating on previous input, making associations or overstimulated. If it is receptive, when a visitor speaks a word or phrase into a microphone connected to a bot, the spoken input is translated by voice recognition software and displayed as text on the screen. This text then triggers the bot to make associations using the *Giver of Names* system. As this perturbation causes it to fall out of synch with the other bots in the community, it communicates these associations with its nearest neighbours, triggering a series of further associations that drive the whole community to diverge from the chant. Without further external stimulation, the new input will drive the community as the dominant stream of its thoughts until it again converges on a common chant.

- ☐ Complementing art research on robotics and artificial intelligence, artists have embraced the relatively new field of artificial life. Such work draws on earlier experiments involving algorithmically generated images, such as Norman White's cellular automata experiments in the late-1960s and Mandelbrot's visualization of fractals in the mid-1970s. Building on similar and related ideas, art research with theoretical foundations in cybernetics, autopoiesis, emergent behaviour and artificial life was vitalized in the 1990s, when it became possible to run simulations of evolutionary systems, such as Tom Ray's Tierra programme, on a personal computer.
- ☐ Artists were quick to enter the fray. One of the first was Michael Joaquin Grey, who, with collaborator Randolph Huff, utilized genetic algorithms processed by a supercomputer to generate forms that were analogous to actual species. *Jelly Lovers* (1991), for example, bears an uncanny resemblance to jellyfish but is the emergent result of exhaustive iterations of relatively simple instruction sets. Karl Sims received the MacArthur Foundation 'genius award' for works such as *Genetic Images* (1993; Works, 150) and *Galapagos* (1997). Modelled on evolutionary theory and the principle of natural selection, these works allow Sims to visualize artificial life forms and animates competitions between them for scarce resources. In *A-Volve*, 1994, an elaborate interactive installation by Christa Sommerer and Laurent Mignonneau (Works, 152), participants select various features to produce their own aquatic artificial life forms. These enter a virtual pool, which is projected onto an actual pool of water, and participants can interact with them by petting them. *A-Life* was hybridized with the Web in Jane Prophet's *TechnoSphere* (1995; Works, 130), which has been described by the artist as 'an evolution simulator that enabled people to create their own creatures and communicate with them as they grow, evolve and die in a virtual three-dimensional environment.'
- ☐ Ken Rinaldo's *Autopoiesis* (2000; Works, 160) constitutes a community of robotic sound sculptures that interact with each other and the audience, resulting in emergent collective behaviour. Biologists Humberto Maturana and Francisco Varela use the term 'autopoiesis' to refer to the tendency of a system to establish its own organizational structure and maintain its internal state of organization, even as it is structurally coupled with other systems. They extend this metaphor from biology at the cellular level to culture at a social level. Similarly, Rinaldo's *Autopoiesis*, like Pask's *Colloquy of Mobiles* (Works, 185) and Rokeby's *n-Cha(n)t*, explores social interactions between robots and between humans and robots. Artistic inquiries involving cellular automata and autopoiesis also have been carried out by the UK collective boredomresearch, in works such as the Web-based project, *Wish* (2006).

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- ☐ In addition to these artistic examples of robotic surrogates, intelligent agents, and cyborgian hybrids that approximate the behaviour of living systems, artists have used a variety of other strategies to interrogate the relationship between the body and electronic technology. One strategy involves creating virtual electronic bodies and avatars. *Bodies INCorporated* (1996–9) by Victoria Vesna and collaborator Rob Nideffer, consists of a Web-based community of avatars created and owned by 'members' who select the traits of their digital surrogates. By participating in the community, members gain shares and symbolically climb the corporate ladder, becoming first 'adepts' then ultimately 'avatars', signifying their diminished attachment to flesh reality and increasing acculturation to cyberspatial reality. *Le Messager* ('The Messenger', 1995;Works, 155), developed by Catherine Ikam and Louis Fléri for IRCAM (Institut de Recherche et Coordination
- ☐ Acoustique/Musique) in Paris, uses a 3D digital scan of a model's head to create an interactive virtual environment. The massive, disembodied head, enlarged to two metres and projected on a screen, recalls the wizard's avatar in Victor Fleming's *The Wizard of Oz* (1939) and anticipates Dr. Know, the holographic fortune-teller in Steven Spielberg's film of Stanley Kubrick's screenplay *Artificial Intelligence: AI* (2000). Sensors in the installation track the motion of the audience and the Messenger uncannily responds as though it were looking at the viewer, following his or her movements with its eyes. To create *BodyScan (IN/OUT)*, (1997; Works, 178), Austrian artist Eva Wohlgemuth had her own body accurately scanned and rendered digitally in three dimensions. Using this as a foundation, the artist subjected her digital body to a wide variety of transformations and re-contextualizations, disembodying her 3D self-portrait from the materiality of corporeal existence and setting it free, so to speak, in virtual reality and cyberspace.

- ☐ Electronic media have begun to cross the threshold between silicon- based systems and biological systems, instigating public dialogue about the social implications of biotechnology. In Kac's *Genesis* (1999; Works, 158), live bacteria were genetically modified to contain – coded within their DNA – a text from the biblical Book of Genesis, 'Let man have dominion over the fish in the sea, and over the fowl of the air, and over every living thing that moves upon the earth.' Participants, both locally and remotely over the Internet, could turn on an ultraviolet light at the installation, causing mutations in the bacteria's genetic code, which in turn caused alterations in the biblical verse after the DNA was decoded and reconstituted as text. Like Roca's *Epizoo*, Genesis raises questions about the shared responsibility of individuals to care for other living beings – in this case, to control environmental factors that are known to cause genetic mutations. Combining a concern with automata, biology and destruction, Joseph Nechvatal's work with genetic algorithms for artificial viruses has resulted in striking images of extraordinary complexity, executed in oil- paint applied by a robotic device (Works, 160). For *Fish and Chips* (2001; Works, 163), the Tissue Culture and Art project collaborated with the SymbioticA Research Group at the University of Western Australia in Perth to grow fish neurons over silicon chips, connected to video and audio output devices, creating a cyborgian confluence of hardware, software and 'wetware', the latter referring to biotechnological media, as distinct from the silicon-based media of computers. This semi- living entity was endowed with the ability to make sound and images – in other words, to make art – begging questions about the future of human interaction with cyborgs whose behaviour may be unpredictable, if not creative.

- ☐ **Simulations And Simulacra (p. 42)**
  - ☐ *Introduction:*
  - ☐ *Works:*
    - ☐ *Myron KRUEGER Video Place, 1974–5 page 166*

      Michael NAIMARK Golden Gate Fly-Over, 1987 page 167

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  - ☐ *Documents:*
    - ☐ *Antonin ARTAUD from The Alchemical Theater, 1938 page 252*

      Myron W. KRUEGER Responsive Environments, 1977 page 252

      Brenda LAUREL The Six Elements and the Causal Relations Among Them, 1986 page 255 N. Katherine HAYLES Embodied Virtuality: Or How to Put Bodies Back Into the Picture, 1996 Bill SEAMAN OULIPO | VS | Recombinant Poetics, 2001 page 259

      Jeffrey SHAW Movies after Film – The Digitally Expanded Cinema, 2002 page 259
  - ☐ *Review:*
    - ☐ Pliny (23–79 AD) recounts the legend of grapes painted by Greek artist Zeuxis (5–4c. BC) that were so life-like that birds attempted to eat them. Not to be outdone, rival painter Parrhasius presented his work to Zeuxis, who attempted to pull back what appeared to be a curtain covering the painting, only to discover that the 'curtain' was the painting. Such accounts attest to the ongoing pursuit by artists to create simulations that are so convincingly true to life that they fool the eye into thinking they are real. Continuing this long tradition, panoramic paintings, photography, stereoscopy

      and cinema in the nineteenth century attempted to provide ever more compelling illusions that emulate the experience of being in the midst of an actual scene. In this context, it is worth recalling that in 1895, some viewers of the Lumière brothers' first publicly presented film were purportedly so afraid of a moving image of a train shown approaching the near-ground of the screen that they fled the theatre! Following this thread, the 1960s saw the initial development of navigable, interactive, computer-generated environments that later came to be known as virtual reality (VR), first used for artistic purposes in the 1970s. The 1970s also saw the emergence of commercial videogames such as PONG in which participants interactively played a simulated game of ping pong viewed on a television screen. In 1982, movie audiences were entranced by the stunning use of computer graphics to envision a digital virtual environment in the stylish sci-fi film *Tron*. Multimedia personal computing enabled the creation of increasingly complex and visually sophisticated computer-games, such as MYST in 1994. A year later, *Toy Story* took honors as the first motion-picture created solely by computer animation. Also in the mid-1990s, the growth of the Web made it possible for simulations and simulacra to exist in cyberspace and for multiple users to share and interact with the same 'consensual hallucination' of a simulated environment.

- ☐ By the mid-2000s, videogame sales exceeded box-office revenues for the motion picture industry in the US, propelled by increasingly compelling illusionism in games such as Halo and Half-Life 2. The convergence of computer-gaming and the Web enabled people from around the world to play with each other over the Internet, competitively or socially, as in The Sims. Artists, such as Mary Flanagan (Works, 181), began using game engines to create works of art and filmmakers did the same, giving rise to the genre known as 'machinima', exemplified by the popular online series, Red vs. Blue. In *Last Riot* (2005–7), Russian collective AES+F cast beautiful, scantly clad youth as protagonists in ultraviolent high-definition 3-D battle-scenes modeled after popular videogames, such as America's Army, which was designed to lure teens into the US military. In 2003, the 3-D virtual world known as Second Life (SL) was launched, creating a platform for 'residents' to view and modify the SL community and participate in its virtual economy, including the production and sale of art. On 18 October, 2006, the population of SL hit one million residents and grew to over twelve million by February, 2008.
- ☐ Simulations are copies that share many attributes with the concrete originals that they represent (i.e. a painting of grapes: real grapes). By contrast, the term 'simulacra' can refer to a form of similarity particular to media culture, wherein distinctions between original and copy become increasingly murky. The originals may no longer exist, may never have existed, or their significance has been dwarfed in comparison to the simulacra, which attains a level or primacy and authenticity that traditionally had been the exclusive province of the original. As Jean Baudrillard has written:

  Abstraction today is no longer that of the map, the double, the mirror or the concept... It is the generation by models of a real without origin or reality: a hyperreal. The territory no longer precedes the map, nor survives it.

Links:

Henceforth, it is the map thatprecedes… that engenders the territory.'[52] [43]

Simulacra may be understood as second-order simulations, or simulations of simulations, wherein that which is being simulated is presented and received not as a simulation but as an original.

- ☐ Les Levine's *Systems Burn-Off x Residual Software* (1969) is an early and insightful meditation on the implications of simulacra and the conditions in which they flourish. Like Levine's earlier video-works, such as *Contact: A Cybernetic Sculpture* (1966; Works, 103), *Systems Burn-Off* was informed by cybernetics, systems theory and media studies but used 'unplugged' media. The work consisted of 1000 copies of each of 31 photographs documenting the March, 1969 opening of the highly publicized 'Earth Works' exhibition in Ithaca, New York. Except for a few that were for sale, the 31,000 images were randomly scattered on the floor and covered with gelatine or stuck to the wall with chewing gum. Levine suggested that the proliferation of mass media was changing knowledge into a second-hand mental experience of simulated representations or simulacra:

All activities which have no connection with object or material mass are the result of software. Images themselves are hardware. Information about these images is software… In many cases an object is of much less value than the software concerning the object…. [I]n a software controlled society … anything seen through the media carries just as much energy as first hand experience… In the same way, most of the art that is produced today ends up as information about art.[53]

- ☐ Electronic media offer artists extraordinary opportunities for producing simulations and simulacra. None of these tools have captured the imagination more than virtual reality (VR). Typically, VR manifests a direct correspondence between real and virtual space and a predictable cause-and-effect relationship between one's actions in the former and the way in which the latter responds to them, i.e., a user's physical movement forward in real space might correspondingly alter his/her apparent position forward in the simulation. By 1970, Sketchpad inventor Ivan Sutherland also had developed the first head-mounted computer display (HMD), a common device for rendering the interactive visual environments of VR.

VR's many uses include pilot-training for the military and travel industry, virtual 'walk-throughs' of a proposed architectural structure, digital reconstructions by archaeologists of a lost building or city and environmental modelling for resource management and prospecting. Such applications demand a close correspondence between reality and virtual reality. Painting, photography and cinema have conditioned viewers to modes of simulated experience that require the suspension of disbelief. Similarly, many VR installations typically utilize immersive environments to help users bracket out their knowledge that the fictional world they are experiencing is the product of computers and projectors in order to imagine it as 'an autonomous reality populated by solid objects and embodied individuals.'[54] By the same token, in an attempt to extend the embodied experience of multimedia, artists have created virtual models that translate between spatial and temporal dimensions.

Marcos Novak's *Liquid Architectures* (begun 1991; Works, 169), for example, consist of virtual, multidimensional, multimedia architectural constructs that evolve over time. Art+Com's *The Invisible Shape of Things Past* (1997; Works, 176) transforms a temporal sequence of two-dimensional video images into a static three-dimensional object. In these examples, VR extends Vera Molnar's ambition to create 'unimaginable' combinations 'never seen before'.

- ☐ Because there are many different types of virtual reality and diverse technologies to support them, VR has taken various forms in art. One important distinction in VR revolves around the degree to which the user is encumbered by the technical apparatus. In unencumbered VR, the user need not wear special equipment; the installation space itself is capable of tracking movement and responsively generating corresponding changes in the virtual environment. In encumbered VR, equipment such as a motion-tracking device, HMD, data-glove that responds to hand and finger motions, tracking and force-feedback mechanisms or other apparatus must be worn by the user. There are trade-offs in terms of the suspension of disbelief in both cases. Unencumbered VR benefits from the realism afforded by the absence of the invasive apparatus that constantly reminds users wearing encumbered technologies that they are in a highly mediated environment. Encumbered VR benefits from more precise interactivity and more responsive output, which enhances the realism of content and responsiveness. As David Rokeby notes in his essay, 'Transforming Mirrors' (see Documents, page 221), some artists do not attempt to suspend the user's disbelief, but rather strive to employ the unmistakably mediated qualities of VR as part of the vernacular of their work in order to draw attention to the material and technical constraints of human machine interfaces. Pushing VR in yet another direction, technologies known as augmented reality and mixed reality seek to join aspects of the direct perception of reality with aspects of the mediated experience of virtual reality, a combination that promises many potential medical, military, commercial and entertainment applications.
- ☐ The first use of VR in art emerged from Myron Krueger's graduate research in human-machine interface design in the late 1960s and early 1970s. Krueger envisioned a playful 'responsive environment', in which one could interact with computers intuitively through body movement and gesture. Nothing of the sort existed. Following a long line of artist- inventors, Krueger's desire for a particular sort of aesthetic experience inspired him to create the technologies required to realize his dreams. Deceptively simple in appearance, Krueger's *Metaplay* (1970) and *Video Place* (1974–5; Works, 166) demanded significant accomplishments in both art and engineering in order to ensure that the system responded smoothly and predictably to the behaviour of the user. In these works, which anticipate the Wii videogame (2006) by over three decades, the participant's gestures trigger a graphic response that is projected on a screen next to the user's shadow. Krueger's pioneering VR art explicitly makes the viewer an active participator in shaping the unfolding action of the piece. At the same time, it results in a performative spectacle that is almost as engaging for a bystander observing

the action as it is for the user. Krueger also has made valuable contributions to the theorization of VR in the context of art: in the mid-1970s he coined the term ‘artificial reality’ to refer to the technologies he and others were developing; and in 1983, he wrote a classic text on the subject, *Artificial Reality*, updated and reprinted in 1991 as *Artificial Reality II*.

- ☐ Due to the expense and technical expertise required to work with virtual reality, little artistic inquiry in this field occurred until the 1990s, when VR research by artists began benefiting from substantial corporate and institutional support. In the early 1980s, Jaron Lanier, who coined the term ‘Virtual Reality’, was head of VPL Research, a company that sold VR products, including data-gloves and head-mounted displays. With these resources, he developed *The Sound of One Hand* (1992), a virtual environment for music performance. This work includes a variety of musical instruments, some simulating conventional ones and others that are simulacra and have no actual referent in the physical world. As head of Visual Research for Canadian software firm Softimage from 1987–97, Char Davies participated in the development of cutting-edge VR software and interface design, producing the artworks *Osmose* (1995; Works, 175) and *Ephemere* (1998).
- ☐ In 1991 the Banff Centre in Canada created VR facilities and began sponsoring residencies that enabled artists to research and experiment with this emerging medium, yielding some of the first VR artworks. These include Catherine Richards’ *Spectral Bodies* (1991), Brenda Laurel’s *Placeholder* (1992), Michael Naimark’s *See Banff!* (1993), and Perry Hoberman’s *Bar Code Hotel* (1994). Based on technology evolved from *Aspen Movie Map* (1978) at MIT, Naimark’s work uses a retro device resembling a nineteenth century Edison Kinetoscope as the interface that allows viewers to experience an interactive, stereoscopic VR representation of Banff.
- ☐ In Germany, the Institute for New Media (INM), founded in 1989 by Peter Weibel at the Städelschule in Frankfurt am Main, was the locus of important VR art research by artists including Weibel, Christian Möller and Ulrike Gabriel (Works, 170) Students, often working in collaborative teams produced outstanding work. For example, Christa Sommerer and Laurent Mignonneau’s *Interactive Plant Growing* (1993) won a Golden Nica at Ars Electronica in 1994 and alumni Constanze Ruhm and Peter Sandbichler exhibited *Kanal* at the Austrian Pavilion at the Venice Biennale in 1995. Spearheaded by Michael Saup, the Supreme Particles was founded at the INM in 1992 and has included various members, including Dutch programmer Gideon May. Indeed, technical genies like May, Bert Bongers, and Sukandar Kartadinata are the unsung heroes of electronic art, and their creative contributions to this growing field deserve wider recognition.
- ☐ At the Zentrum für Kunst und Medientechnologie (Center for Art and Media Technology, ZKM) in Karlsruhe, where Jeffrey Shaw was founding director of the Institute for Visual Media from 1992–2003, artist residencies and superb resources and personnel (May was software developer and systems administrator there from 1990–3, followed by Christian Ziegler and Volker Kuchelmeister) enabled international artists to develop important work, including Luc Courchesne’s *Portrait One* (1990; Works, 168), Tamas

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Waliczky's *The Forest* (1993), Miroslaw Rogala's *Lovers Leap* (1994–5; Works, 172), Jill Scott's *Frontiers of Utopia* (1995; Works, 174), Masaki Fujihata's *Beyond Pages* (1995; Works, 173), Toshio Iwai's *Piano as an Image Media* (1995; Works, 113) and Bill Seaman's *The World Generator* (1996–8). Indeed, the mid-to- late 1990s at the ZKM was a heyday of artistic and technological innovation involving electronic media.

- ☐ In the US, universities have been a primary site for art research involving VR. At the Interactive Telecommunications Program at New York University, Camille Utterback and Romy Achituv created *Text Rain* (1999), a piece that carries forward the spirit of Krueger's playful approach to unencumbered VR. Participants stand or move in front of a large projection screen where they see a mirrored video projection of themselves in black and white, combined with a colour animation of falling text. Like rain or snow, the text appears to land on participants' heads and arms. The text responds to the participants' motions and can be caught, lifted and then let fall again, landing on anything sufficiently dark and falling whenever that obstacle is removed.

  In a similar manner, artist Victoria Vesna and scientist James Gimzewski, both at UCLA, collaborated on *Zero@Wavefunction* (2003), which allows participants to interact with and experience the dynamic elasticity of virtual 'Bucky Balls', spherical nano-scale molecules that resemble the geodesic domes designed by Buckminster Fuller. Taking cues from Charles and Ray Eames' film, *Powers of Ten* (1977), *Nanomandala* (2004) enables viewers to interact with a mandala, projected on an eight-foot diametre disk of sand, at diverse scales, fluidly telescoping back and forth from the molecular structure of a single grain of sand (imaged with a scanning electron microscope) to the whole mandala of Chakrasamvara.
- ☐ Development of the versatile VR technology known as the CAVE (Cave Automatic Virtual Environment or Computer Automated Virtual Environment) began in 1991, led by computer scientist Tom DeFanti and artist Dan Sandin at the Electronic Visualization Laboratory (EVL) at the University of Illinois Chicago. CAVEs typically afford stereoscopic views that are projected on one or more walls of a cubic space. The projections are corrected so that they blend seamlessly among up to six walls (including floor and ceiling), making the physical corners disappear and producing a continuous sense of space. More typically a CAVE will have two to four sides; a six-sided CAVE provides an illusion of continuous space that extends infinitely in all directions and completely surrounds the viewer, offering a vivid experience of 3-D immersion. The interactive and immersive qualities of VR vastly extend the ability to perceive and understand objects and datasets greater than three dimensions. CAVEs lend themselves to unencumbered modes of interaction, yet they may incorporate a variety of interface devices to enhance navigation.
- ☐ Sandin has collaborated closely with engineers, mathematicians and scientists to produce stunning visualizations of complex systems such as Quaternion Julia Sets – four-dimensional objects generated from fractals. These visualizations also were made available online using VRML, a Web-

based protocol that emulates VR, so that general audiences could interact with them. *Oort Continuum* (1994–6; Works, 174), a project supervised by Sandin and programmed by Marcus Thiebaux (then a graduate student) comprises a meta-world that enables access to multiple virtual realities created by EVL students. At the National Center for Supercomputing Applications, artist Donna Cox has collaborated with scientists and engineers to develop visualizations such as the Academy Award nominated IMAX film, *Cosmic Voyage* (1996) and *Passport to the Universe* (2000; Works, 189), the inaugural film for the domed theatre at the Hayden Planetarium in New York City. Cox also worked with Thiebaud and Robert Patterson to develop the software framework Virtual Director, a networked, multi-user VR application that enables researchers to interact remotely with one another in local CAVEs, sharing and modifying data in a virtual reality environment.

- ☐ Jeffrey Shaw's early expanded cinema events of the 1960s laid the foundations for interactive computer simulations and VR installations, including works designed for the CAVE beginning in the 1990s. In *Movie-Movie* (1967), a happening created together with Theo Botschuijver, Sean Wellesley-Miller and Tjebbe van Tijen for the Fourth Experimental Film Festival at Knokke-le-Zoute, film, slides and liquid-light show effects were projected on and through a thirty foot inflatable plastic dome and the people interacting in and around it. The artist intended for the air-filled structure, which consisted of a transparent outer membrane and inner white surface, to transform the traditional flat cinematic screen into a 'three dimensional kinetic and architectonic space of visualization'. In 1993 at the MultiMediale 3 in Karlsruhe, Shaw presented a version of his VR art gallery, *The Virtual Museum* (1991) using a new projection technology known as EVE (Extended Virtual Environment) developed at the ZKM. Reminiscent of *Movie- Movie*, EVE's domed, interactive visualization space enables a viewer to direct the projection of video along its hemispherical surface. In *The Golden Calf* (1994), Shaw employed a small hand-held LCD monitor tethered to a pedestal that enabled users to walk around and interactively examine a virtual 3D bovine simulacrum – a found object in the Silicon Graphics software library. In *conFIGURING the CAVE* (1996; Works, 177), he and collaborators Agnes Hegedüs and Bernd Lintermann created a four-sided CAVE that incorporates a novel interface – a mannequin – which enables the user to navigate seven distinct audiovisual domains. Much of the work's densely composed symbolic imagery is based on Jewish mysticism and the kabbalah, which, itself may be considered a simulacra: a structural mapping of an unknowable, virtual territory, comprised of various interconnected orders of matter, consciousness and spirit. *conFIGURING the CAVE* is, then, both a simulation and simulacrum that examines multiple levels of simulation by using a human surrogate as its interface, incorporating various tiers of symbolic mapping, in virtual reality.

- ⊟ **Exhibitions, Institutions, Communities, Collaborations, (p. 47)**
  - ☑ *Introduction:*
    - ☑ *Although the history of art has cultishly celebrated the individual genius, the field increasingly has recognized the importance of exhibitions, institutions and communities in shaping the production, reception and historical contextualization of art. Significant exhibitions have provided a public context*

for popular audiences to experience innovative work and for that work to be the subject of critical analysis. Institutions, including universities, corporations, governments and foundations, have provided financial support and technical expertise that enabled facilities to be created and complex projects realized, and communities of artists, engineers, scientists, critics, historians and publishers have provided a nurturing environment in which ideas, experiences, and resources could be shared and expanded upon. Scientists increasingly have come to realize the value of artists not just as producers of attractive visualizations of data but as creative partners, whose insights and methods can fundamentally alter and expand their intellectual vision, spurring innovation and invention in the laboratory.

- ☐ *Works:*
  - ☐ *Leonardo/ISAST page 183*
    E.A.T '9 evenings: theatre & engineering'
    The Art and Technology Program (A&T) page 184
    WGBH, Fred Barzyk/New Television Workshop page 184
    'Cybernetic Serendipity'
    'Software' page 185
    The Kitchen page 186
    Ars Electronica page 187
    The Daniel Langlois Foundation (DLF)
    American Museum of Natural History (AMNH) in collaboration with the National Aeronautic and Space Administration (NASA) The Search for Life: Are We Alone? 2002 page 187
    ZKM page 188
    rhizome page 188
    Intel Corporation ISEA page 189
- ☐ *Documents:*
  - ☐ *Billy KLÜVER Theater and Engineering: An Experiment, 2. Notes by an engineer, 1967 page 262*
    Billy KLÜVER and Robert RAUSCHENBERG The purpose of Experiments in Art and Technology, 1967 page 263 Douglas DAVIS Art & Technology – Conversations. Gyorgy Kepes interviewed by Douglas Davis, 1968 page 264 Jasia REICHARDT Cybernetic Serendipity, 1968 page 264
    Howard WISE TV as Creative Medium, 1969 page 265
    Jack BURNHAM Notes on art and information processing, 1970 page 265
    Jane LIVINGSTON Thoughts on Art and Technology, 1971 page 267
    Frank POPPER Introduction to 'Electra: Electricity and electronics in the art of the XXth century', 1983 page 267 Jean-François LYOTARD Les Immatériaux, 1985 page 269
    Donna J. COX Using the Supercomputer to Visualize Highter Dimensions: An Artist's Contribution to Scientific Visualization, 1988 page 270
    LA POCHA NOSTRA (Guillermo GÓMEZ-PEÑA, Michéle CEBALLOS, Violeta LUNA, Guillermo GALINDO) The 14 Activist Commandments for the New Millennium page 271
    Victoria VESNA Toward a Third Culture: Being In Between, 2001 page 271
    Steve DIETZ Interfacing the Digital, 2003 page 272
- ☐ *Review:*
  - ☐ The aesthetic, technical and financial challenges of electronic media have demanded that artists perform non-traditional tasks and form unconventional

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partnerships. These exigencies spurred the formation of communities of like-minded individuals and catalyzed collaborations with scientists and engineers. Artists theorized their own work, developed publishing venues and gained support from academic institutions, not-for-profit organizations and corporate and public sponsors. These alliances also characterize the production of major works of electronic art as well as many of the important historic and contemporary exhibitions that popularized the idea of joining art and technology. Increasingly, scientists and engineers are recognizing that artists make valuable collaborators who contribute to research and invention not just by making pretty visualizations of data but by asking provocative questions, offering alternative perspectives and stimulating creativity and innovation.

- ☐ In the politically charged environment of the US in the 1960s, the Vietnam War, the Cold War, the ‘Space Race,’ growing ecological awareness and rising concerns about what President Dwight Eisenhower described as the military- industrial complex, led many visionary artists, curators and engineers to believe that art could play an important role in humanizing technology. Indeed, the idea of joining art and technology seemed captivating, if not necessary, to prominent artists such as Cage, Rauschenberg and Paik. Similarly, the Artist Placement Group (APG), founded in London in 1966 by Barbara Steveni and John Latham with Jeffrey Shaw and Barry Flanagan, placed artists within corporate contexts, where their unique vision and problem-solving capabilities could contribute to the transformation of industry and ultimately, society in general.

  Corporations have generously sponsored the creation and exhibition of work joining art and technology. Philips Corporation, for example, supported the work of artists including Le Corbusier, Schöffer and Ihnatowicz from the 1950s to the 1970s. The ‘Software’ exhibition at the Jewish Museum (1970; Works, 185) was sponsored by American Motors Corporation and IBM. The Art and Technology programme (A&T) at the Los Angeles County Museum of Art (1967–71; Works, 184) and the ‘Magic Theater’ exhibition organized by the Nelson Gallery of Art in Kansas City (1969) brought together artists with many industry partners, ranging from Lockheed Aircraft Corporation to Universal Studios, that helped fund and produce technically complex work. It must be noted that some artists were wary of that work produced under the aegis of such sponsors would serve to whitewash tarnished corporate images that should remain sullied. Jean Toche withdrew his proposed piece about air pollution from ‘Software’ when he learned that the lead sponsor was American Motors; indeed, art and industry often make strange bedfellows.[55]
- ☐ Memorable outcomes from A&T included Newton Harrison’s *Glow Discharge Tubes*, Claes Oldenberg’s *Giant Ice- Bag*, Robert Rauschenberg’s *Mud Muse* and a spectacular optical mirror environment by Robert Whitman and John Forkner. These works were exhibited in the US Pavilion at the 1970 World Fair, EXPO 70, in Osaka, Japan. ‘Magic Theater’ resulted in a variety of works including James Seawright’s *Electronic Peristyle* (Works, 66) and Terry Riley’s *Time Lag Accumulator*. Software joined technological objects

with art objects, claiming to make no distinction between them and included a computerized gerbil environment by Negroponte, Haacke's teletype machines, Sheridan's 3M colour photocopier and a hypertextual catalogue by Ted Nelson.

- ☐ Artists working with electronic media since the mid- twentieth century eagerly collaborated with scientists and engineers to explore the potential of interdisciplinary research as a means of producing innovative work. Perhaps the most prominent historic example of this tendency is E.A.T. The group's first event, '9 evenings: theatre and engineering' (1966; Works, 184) consisted of a collaboration among ten artists and thirty engineers that yielded nine evenings of technologically enhanced performances and several patents. Seen by an audience of 10,000, the project benefited from 8500 hours of donated engineering expertise, some 'midnight equisitions' from Bell Labs and significant personal donations from Klüver, Rauschenberg, and others. Klüver eventually left Bell Labs to lead E.A.T.'s effort to make 'materials, technology and engineering available to any contemporary artist.'[56] At its peak, the organization could boast of twenty-eight chapters in the US and some 6000 members. Among its many subsequent projects, E.A.T. was commissioned to design and programme the Pepsi Pavilion at Expo 70, an endeavour that stretched the group's creative, technical and organizational limits, resulting in a remarkable spectacle of artistic and engineering wizardry.[57] Following the Apollo 11 lunar landing in 1969, signifying America's technological supremacy in the 'Space Race', in 1970 art and technology appeared to become, at least momentarily, official US art, dominating both the US Pavilion and the Pepsi Pavilion at the 1970 World Fair, seen by an estimated 1,000,000 visitors.
- ☐ In addition to encouraging its engineers to work on '9 evenings', beginning in the early 1960s Bell Labs hosted artists in residence including James Tenney, Stan VanDerBeek (Works, 82) and Lillian Schwartz (Works, 86), who worked alongside staff researchers and contributed to the development of sound synthesis and computer graphics and animation. Residency programmes at Bell, 3M and other companies, along with partnerships generated by A&T and 'Magic Theater', inspired subsequent corporate programmes at XEROX PARC (1993–9), Interval Research (1992–2000), the Intel Corporation (1996 – present; Works, 188), the Advanced Telecommunication Research Labs (ATR) in Kyoto, Japan, and the Artists in Labs programme co-ordinated by the Hochschule für Gestaltung und Kunst, Zürich (2004– present). Researchers in diverse fields are increasingly recognizing that the intellectual challenge and excitement of working as part of a transdisciplinary team often generates insights and produces results that could not have been achieved by using the methods and techniques of any single discipline. Indeed, an idealized goal of such research is the synergistic creation of hybrid end-products that could only have been imagined and executed as a result of collaboration. As Florian Schneider has noted, 'Collaborations are the black holes of knowledge regimes. They willingly produce nothingness, opulence and ill behaviour. And it is their very vacuity that is their strength... It does not entail the transmission of something from

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those who have to those who do not, but rather the setting in motion of a chain of unforeseen accesses.'[58]

- ☐ Although the public fascination with art and technology in the 1960s was short-lived, the annals of the journal *Leonardo* (Works, 183) demonstrate that artists, scientists and engineers remained committed to the potential of collaborative research throughout the 1970s and 1980s. Artists whose research compelled them to work with technology – and especially with computers, which at the time were prohibitively expensive and far from user-friendly – gravitated to universities where they could have access to the specialized equipment, technical support and intellectual climate that enabled them to develop their work. Examples of this migration in the US include Dan Sandin at the University of Illinois at Chicago and Charles Csuri at The Ohio State University, both of whom became faculty members in the late 1960s and have participated in innovative collaborative research. In the belief that 'if we can control the "dots" we can do anything,' David Em sought and gained access to computers at Xerox PARC in 1975 and Jet Propulsion Lab (JPL), where he was artist in residence from 1976–84. Having cut their teeth working on *Aspen Movie Map* at MIT in the mid-1970s, artists Rebecca Allen, Scott Fisher and Michael Naimark have balanced academic and industrial research throughout their careers.
- ☐ While electronic media went underground, so to speak, in the 1970s, important exhibitions and symposia took place throughout Europe in the 1980s: Ars Electronica in Linz, Austria (annual since 1979); Electra (1983) and Les Immateriaux (1985) in Paris; the Venice Biennale (1986); V2 Organization's Manifestation for the Unstable Media ('s Hertogenbosch, Netherlands, annually 1986–92); the International Symposium of Electronic Art (ISEA, launched in Utrecht, 1988; held internationally); and the WRO Media Art Biennale (Wroclaw, Poland, since 1989). These events played a major role in developing an international community with a common interest in the intersections between art, science and engineering and in forging the practical and theoretical and institutional foundations of what has become known as new media.
- ☐ Despite the vitality and dynamism of this emerging community, it was confined to the margins of the larger international art world in the 1980s. Mainstream galleries and museums embraced various types of neo-expressionism along with diverse forms of neo-conceptualism and photo-based practices under the rubric of post-modernism. While historians and critics interpreted these developments via the lenses of semiotics, critical theory and poststructuralism, many artists using electronic media were posing arguably more profound challenges to modernist conventions. For example, Ascott's *La Plissure du Texte* (1983) and *Organe et Fonction* (1985) questioned notions of authorship and originality, transformed the relationship between the artist, artwork and audience, and created behavioural, time-based, process-oriented, and interactive contexts for emergent, dialogical exchange, in both local and remote environments. Moreover, these works exemplified and expanded key principles of post-modernity: the notions of readerly texts and textual pleating theorized by Roland Barthes in the 1970s, the intertextual invocation of 'différance'

evidenced in Jacques Derrida's *Glas* (1974) and the principle of 'paralogy' propounded by Jean-François Lyotard in *The Postmodern Condition* (1979).

- ☐ A second wave of enthusiasm towards art and technology emerged in the 1990s with advances in personal computing, the advent of the Web and a booming E-commerce economy. Combined with the fall of Berlin Wall, signalling the end of the Cold War and the televised spectacle of US military technology in the first Gulf War, public fear of technology waned – at least in the US and Europe. Moreover, new facilities were built, providing a robust institutional infrastructure and a growing number of major exhibitions took place internationally.
- ☐ In Europe, investment in electronic art is recognized as a vital force for cultural regeneration, economic development, and the growth of creative industries. Funding from municipal, regional, national and EU sources has helped the field flourish, particularly in Austria, Germany, Netherlands, and the UK. Ars Electronica's annual prize and symposium have continued to support innovative work and lively dialogue. The construction of the Ars Electronica Center (AEC; Works, 187) in 1995 provides not only a formal home for the event but a museum to display its permanent collection, production resources and a VR CAVE. Also in 1995, V2 relocated to Rotterdam, where it offers a wide range of programmes, including artist residencies, production facilities and technical support, scholarly publishing and the biennial Dutch Electronic Art Festival (DEAF). The Netherlands Media Art Institute has an extensive video collection and offers diverse programmes, including residencies, exhibitions and events, including the Sonic Acts festival. ISEA festivals (Works, 187)have been held in Europe, Australia, US, Canada, Japan, across the Baltic Sea (Helsinki, Stockholm, Tallinn, via a connecting boat) and Singapore. Begun in 1988, the Berlin VideoFilmFest morphed into the annual Transmediale festival. In the UK, The Arts Catalyst, CRUMB and Tate have supported new media production and exhibition by commissioning work, curatorial scholarship and exhibitions. In 1999, the ZKM (Works, 188) came under Weibel's leadership and moved into expanded, permanent quarters that include a Media Museum to display its permanent collection and additional space to mount extensive exhibitions, such as net_condition (1999) and Lichtkunst aus Kunstlicht (2005–6), documented with well- illustrated, scholarly catalogues. These established institutions werejoinedbytheopeningin2007ofthe LABoralCentrode Arte y Creación Industrial in Gijón, Spain.
- ☐ Major exhibitions in North America were organized in the 1990s and early 2000s by the Whitney Museum, Walker Art Center, Wexner Art Center, Guggenheim Museum, Eyebeam and San Francisco Museum of Modern Art. Since 1981, SIGGRAPH (Special Interest Group Graphics of the Association for Computing Machinery) has sponsored annual exhibitions of computer art organized in conjunction with its industry-focused conference held in various cities and the Boston Cyberarts festival has been held biennially since 1999. The ISEA festivals in Montreal (1995) and Chicago (1996) included extensive exhibitions. The Banff New Media Institute in Alberta Canada has produced diverse programmes, including symposia, think-tanks, residencies, collaborations and exhibitions. In Montreal, the Images du Futur

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festival was active from 1986–96 and in 1997 the Daniel Langlois Foundation (Works, 187) began building extensive archives and started sponsoring fellowships for artists and researchers.

- ☐ In Japan, the InterCommunication Center supports a wide range of exhibitions, prizes, programming and publishing and the Tokyo Metropolitan Museum of Photography has hosted numerous exhibitions of electronic art, including the 10th Japan Media Arts festival in 2006. New conferences and festivals have emerged around the world, including Transmediale in Berlin, Art + Communication in Riga, Microwave in Hong Kong, Biennial of Electronic Arts Perth, the Beijing International New Media Arts Exhibition and Symposium, and ZERO1, first held in 2006 in conjunction with ISEA in San Jose.
- ☐ The broad cultural fascination with new media has generated a substantial literature. *Art Journal* (US), *Kunstforum* (Germany), *Artlink* (Australia) and *Parachute* (Canada) all have published special issues dedicated to art, science and technology, joining *Leonardo* as important forums for scholarship. New journals emerged internationally, including *Mediamatic* (Netherlands, 1985), *Neural* (Italy, 1993). *MUTE* (UK, 1994), *Convergence* (UK, 1995), *Digital Creativity* (1995), *Intelligent Agent* (US, 1996), *Artbyte* (US, 1998–2001) and *a mínima* (Spain, 2000), while listserves, hosts and E-journals including ctheory.net, Rhizome.org (Works, 188), *The Thing*, *Telepolis*, *Noema* and *Leonardo Electronic Almanac* have spawned communities of affinity and additional contexts for discourse on electronic media. Other online resources, including *MediaArtNet*,*Multimedia: From Wagner to Virtual Reality*, and the *Leonardo Pioneers and Pathbreakers* project provide multimedia content and critical insights pertaining to the intellectual and aesthetic genealogy of new media, an invaluable resource for teaching and learning. Despite the slowness of art historians to enter the fray of theorizing and historicizing the use of electronic media in art, a substantial number of anthologies and monographic studies from various disciplines published in the 1990s and 2000s have helped make sense of this growing and diverse field from myriad perspectives. The role of artists is important in this regard. Indeed, texts written by artists have played a central, although under-recognized, role in the critical and theoretical development of art and its discourses. This is especially the case in experimental art, where artists often anticipate art historical and critical appraisal by many years.
- ☐ Electronic art poses numerous challenges to curators and museums, ranging from the presentation and maintenance of works that are vulnerable to break-downs, to the custodianship and preservation of such work, complicated by rapid cycles of technological obsolescence. Such challenges were not new in the 1990s and advocates for electronic art recognized that they had to be addressed in order for collectors and museums to acquire and exhibit work made with technological media. This seal of approval remains an important but elusive source of validation in the 2000s, though in 2001, Bill Viola's *The Quintet of Remembrance* (2000) became the first work of video art to enter the permanent collection of the Metropolitan Museum of Art, New York. The integration of major works by Gary Hill, George Legrady and Tony Oursler into the architectonic fabric of the Seattle Public Library (2004)

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makes perhaps an even bolder statement of the acceptance of electronic art by public institutions, albeit not necessarily museums.

- ☐ In support of Web-based works of art, curator Steve Dietz organized the landmark exhibition 'Beyond Interface' in 1998, and many other exhibitions of 'net.art' can be accessed through the Whitney Museum's *Artport*, a comprehensive portal for such work. Although electronic art, especially Web-based work, has remained peripheral to mainstream contemporary art, commercial galleries dedicated to it are contributing to its acceptance, along with growing interest in the field by critics and scholars, to say nothing of artists, collectors, institutions and the general public. As digital media play an increasingly important role in both art education and commercial production, and as emerging generations of artists are trained to use them as traditional materials and techniques, it is not far-fetched to imagine that new media will become firmly entrenched in the centre of contemporary fine art, much in the way video came to prominence in the 2000s.
- ☐ The difficulties of producing and exhibiting electronic art stem, in part, from the nature of the media themselves, which often demand institutional and community support structures at odds with traditional modes of art-making and generate works that resist conventional models of public display. For example, when Norman White first gained access to computer networking in the late 1970s, he was excited by the prospect of being able to use it to explore the medium's potential for art-making. The prohibitive cost of long-distance telephone calls prior to deregulation posed one problem. But White confronted an equally vexing dilemma: he did not know any other artists who were online with whom he could network and explore the medium's artistic potential. By the early 1980s, corporate sponsorship of the computer networking systems helped overcome the first hurdle. As for creating a network, artist's groups and alternative spaces such as Open Space in Victoria, Western Front Society in Vancouver and World Pool in Toronto created awareness of the medium in Canada, provided access to it and forged international connections with similar groups internationally, such as Center for New Art Activities and the Alternative Media Center in New York, La Mamelle in San Francisco and with artists and groups at many universities around the world. The development of telematic art, therefore, demanded not only access to technology (initially provided by corporate and university sponsors) but interconnected communities of users. As Ascott theorized in 1983 in 'Art and Telematics' (see Documents, page 229), the value of computer-networking as an art medium arises from a collaborative, participatory process that enables the emergence of a distributed form of collective consciousness. As public interest grows in such artforms, galleries and museums will undoubtedly develop more effective ways of preserving, collecting, and sharing it.
- ☐ Just as the production of electronic art often demands the formation of communities and institutions and frequently leads to the production of open-ended exchanges rather than concrete works, some art and science research agendas demand collaboration between experts in a variety of fields without a clearly defined or functional outcome. The performances in '9 evenings', for example, were possible only as a result of teamwork between artists and

engineers. Working alone, neither the artists nor the engineers could have accomplished the end result. As in the late 1960s and 1970s when artists whose practices demanded access to technology gravitated towards universities, so in the 1990s and 2000s, leading artists have sought out collaborative contexts at universities in order to explore the potential of practice- based transdisciplinary research. Such research challenges the boundaries of traditional disciplinary inquiry and education, generating hybrid outcomes and practitioners. As the number of such hybrid practitioners increases, their impact on the centrality of technology and science in the production of art and design (and vice-versa) will force a reconsideration of the canons of art history and the histories of science and technology. Ideally, such work will create new forms and structures of meaning that expand the languages of art, design, engineering and science, and that open up new vistas of creativity and invention.

- ☐

- ☐ ***Global Summary: (Rough Draft)***
  - ☐ ***Survey (p. 12)***
    - ☐
  - ☐ ***Motion, Duration, Illumination (p. 16)***
    - ☐
  - ☐ ***Coded Form and Electronic Production (p. 22)***
    - ☐
  - ☐ ***Charged Environments (p. 27)***
    - ☐
  - ☐ ***Networks, Surveillance, Culture Jamming (p. 32)***
    - ☐ The understanding from global to local resulted in Roy Ascott's work. To collapse time and space (globally) and to democratize technology that is left for the corrporations, researchers, and government.
    - ☐ Eduardo Kac is integrating the Networks to create a cybernetic interaction between bird and plant. He notes that the human element is key because as a parameter it enhances the behavior of the bird element of the system.
    - ☐ Precedents of using the technology for and agains has led to artworks that show how societal biases are demonstrated by use and power relations.
    - ☐ Technology surveillance and disclosing the rules of technology and normative culture have inspired artist to outline and disclose how that method is demonstrated in a work of art.
    - ☐ The use of GPS technology, surveillance technology and the idea of tagging and marking through lasers are another form of understanding how property, civil rights and the issues of humanity are being integrated to a larger cybernetic global culture.
  - ☐ ***Bodies, Surrogates and Emergent Systems (p. 38)***
    - ☐ *Artists have combined the arts, technology and science to blur the lines between living matter and non living matter. Using cybernetics to hack and communicate with plants and insects. To see the limits of communication and interaction between species.*

Art And Electronic Media (Edward Shanken) Survey pp. 12-53 (41)

Links:

- ☐ *Robots are used as not only surrogates in action but in purposee. Scenarios of survival and the evaluation of such systems are inherent of some of the works of the tim. Revealing the hidden nature of material.*
- ☐ ***Simulations And Simulacra (p. 42)***
  - ☐ *Virtual reality technologies essence is to immerse bodies in space and to formalize a symbolic language. This formalization of space, technology, science and aesthetics creates the sense of immersion. The capacity of which can be seen since its discovery in the 1960's as a beginning of the full integration of immersive information and the ability to communicate spatial data.*
  - ☐ *Virtual reality can be seen as a process of the quantification of data in a spatial paradigm . Philosophically the questions open new territories of insight and investigation. Questions about embodiment and scale can be traced back to our associations to a physical envelope.*
  - ☐ *The future of virtual reality seems to be in abstractions and in the language bridging knowledge at an immersed scale versus knowledge at a global scale. Similar knowledge that can be gained in Data visualization. Scientific Visualization relies on the immersive characteristics of a systems function and purpose.*
- ☐ ***Exhibitions, Institutions, Communities, Collaborations (p. 47)***
  - ☐ Exhibitions were created by community members that wanted to collaborate on larger projects. Projects that challenged their limits of creativity, knowledge and technical abilities. The collaborations created partnerships in sharing resources that only were available by companies, research universities and Museums/ Inventors. The unification and the creation of the field of new media and art/science collaboration was a movement out of need to find ways of making. Making beyond the limitations but to find means in creating work.
- ☐ ***Final Drafts***

Experience and Abstraction:the Arts and the Logic of Machines (Simon Penny) Presented Digital Arts and Culture (2007) pp. 1-18 (18) **Untitled #1**

- ☑ _Article Summary:
  - ☑ Published: Fibreculture Online Journal ; Presented Digital Arts and Culture
  - ☑ Author: Simon Penny
  - ☑ Experience and Abstraction:the Arts and the Logic of Machines pp. 1-18
  - ☑ Year: 2007
  - ☑ Publisher:
- ☐ _Bibliography
  - ☐ Experience and Abstraction:the Arts and the Logic of Machines (Simon Penny)Presented Digital Arts and Culture (2007) : Published Fibreculture Online Journal, #11, Jan 2008 pp. 1-18 (18)
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
    - ☐ Symbolic Computation en.wikipedia.org–
    - ☐ Object oriented programming en.wikipedia.org–
    - ☐ Skeuomorph en.wikipedia.org–
    - ☐ Gestell en.wikipedia.org–
    - ☐ ontology en.wikipedia.org–
    - ☐ Autopoiesis en.wikipedia.org
      - ☐ pespmc1.vub.ac
      - ☐ "**Autopoiesis**" (from Greek αὐτο- *(auto-)*, meaning "self", and ποίησις *(poiesis)*, meaning "creation, production") refers to a system capable of reproducing and maintaining itself. The term was introduced in 1972 by Chilean biologists Humberto Maturana and Francisco Varela to define the self-maintaining chemistry of living cells. Since then the concept has been also applied to the fields of systems theory and sociology.
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
    - ☐ Concepts
    - ☐ Online Sources:
- ⊟ _Outline
  - ⊟ **Abstract:**
    - ☑ This paper is concerned with the nature of traditions of Arts practice with respect to computational practices and related value systems.
    - ☐ At root, it concerns the relationship between the specificities of embodied materiality and aspirations to universality inherent in symbolic abstraction.
    - ☐ This tension structures the contemporary academy, where embodied arts practices interface with traditions of logical, numerical and textual abstraction in the humanities and the sciences.
    - ☐ The hardware/software binarism itself, and all that it entails, is nothing if not an implementation of the Cartesian dual. Inasmuch as these technologies reify that worldview, these values permeate their very fabric. Social and cultural practices, modes of production and consumption, inasmuch as they are situated and embodied, proclaim validities of specificity, situation and embodiment contrary to this order. Due to the economic and rhetorical force of the computer, the academic and popular discourses related to it, are persuasive.
    - ☐ Where computational technologies are engaged by social and cultural practices, there exists an implicit but fundamental theoretical crisis. An artist, engaging such technologies in the realization of a work, invites the very real possibility that the technology, like the

Information Arts: Ch. 3.4 Space pp. 260- 281 **Links:**

- ☐ _Article Summary:
  - ☐ Information Arts: Intersections of Art, Science, and Technology
  - ☐ Author: Stephen Wilson
  - ☐ Ch. 3.4 Space pp. 260- 281
  - ☐ Year: 2003
  - ☐ Publisher: MIT Press
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
    - ☐ Concepts
      - ☐ Alien en.wikipedia.org–
      - ☐ Space en.wikipedia.org–
      - ☐ OutserSpace en.wikipedia.org–
      - ☐ Nasa en.wikipedia.org–
      - ☐ Satellites en.wikipedia.org–
    - ☐ Online Sources:
    - ☐ Ars Astronautica www.arsastronau
- ⊟ _Outline
  - ⊟ **Artistic Interest in Space** (p. 261)
    - ☑ Astronomical and cosmological research and space science promise to have great impact on humanity. Historically, the arts paid close attention to the heavens.
    - ☐ Some artists have started the effort. NASA even sponsors a limited Space Art project. Several organizations around the world promote artistic involvement, such as OURS Foundation, Journal Leonardo Space Project, and Ars Astronautica.
    - ☐ The Leonardo Space Project introduction includes statements from several of those involved. Roger Malina, who is editor of the journal *Leonardo* in addition to being an astrophysicist, notes that artists helped prepare our culture for space research:
    - ☐ The space age was possible because for centuries the cultural imagination was fed by artists, writers, and musicians who dreamed of human activities in space. Now, with the end of the cold war, the role of artists and writers is again crucial in defining our future vision of space—and will once again be instrumental in incorporating the facts and discoveries of the space age into the cultural imagination.[1]

- ☐ Arthur Woods, head of the OURS Foundation, sees space research as essential to human survival and artists as critical communicators of that need. In his statement "The Next Millennium: A Space Age or a Stone Age?" he notes:
- ☐ Human destiny on Earth is irrevocably linked to human destiny in space. The continued explora- tion and exploitation of the space environment are essential to the future survival and prosperity of the human species. Using space resources to meet the growing needs of humanity on Earth is by far the most optimistic solution to many of the problems facing humanity as it enters the new millennium. The key to this solution is not in technology alone because most of the necessary technology already exists, but rather in manifesting a deep and global understanding of the human situation vis-a-vis the dimensions of the Universe. Thus the cultural reasons for exploring space may prove to be even more compelling than the political and scientific reasons that have been responsible for humanity's astronautical activities up until now.

  The future of space activities, the future of humanity, and perhaps even the future all life on Earth is in need of skilled communicators possessing the knowledge and understanding of the scientist combined with the intuition and sensitivity of the artist.[2]
- ☐ These statements suggest that the primary achievement of art that is concerned with space lay in its stimulation of public imagination and the understanding of space re- search.
- ☐ In his "Brief History of Space Art," Arthur Woods traces the initial examples of space art from scientific illustration to book illustration and science fiction movies. Practically, this builds support for funding.
- ☐ While these are important functions, they are not the only ones. Art can function in other ways: stretching the conceptualization of research, suggesting new research direc- tions, introducing commentary and perspectives from outside the discipline, and helping to interpret the implications of research: "Whereas artists and writers of the past created the visions upon which the present space program has been built, today many artists serve the space community by helping to visualize the future developments and give form to developing technologies."[5]
- ☐ In his paper "The Role of the Artist in Space Exploration," Roger Malina lists seven categories of space art:
- ☐
  1. *Fine art which exploits sensory experiences generated through space exploration.*
  2. *Art which expresses the new psychological and*

philosophical conceptions developed

through the exploration of space.

3. *Art in space, viewed from Earth.*
4. *Art on Earth, viewed from space.*
5. *Art in space, viewed in space.*
6. *The applied arts, such as space architecture, interior design, and furniture de-*

sign.

7. *Fine art which takes advantage of new technologies and materials created through*

space activities such as satellites.[6]

- ☐ artistic response to the search for extraterrestrial intelligence. Woods notes that the main- stream art world has not accepted much of this art.

- ⊟ **Views from Space** (p. 263)
  - ☑ Some of the most powerful impact has been derived from the new views of the earth offered from space.
  - ☐ For example, the pictures of the earth globe glowing blue in its shroud of clouds had enormous impact. For the first time people could see the earth as a unified whole system with almost no indications of the political divisions that seem so important to the earth's inhabitants. One example is Stewart Brand's publishing of the *Whole Earth Catalog,* partially inspired by this view. The "whole earth" became an icon of the environmental movement.
  - ☐ Artists also sought to create artworks that built on this new perspective.
  - ☐ in 1980 Tom Van Sant created a work called *Reflections from Earth,* and in 1986 *Desert Sun,* which consisted of mirrors to be viewed from satellite or space. www.tomvansa
  - ☐ Van Sant was part of the group of artists working with Otto Peine at the Center for Advanced Visual Studies at MIT and their "Skyart" events.

Information Arts: Ch. 3.4 Space pp. 260- 281 **Links:**

- ⊟ **Pierre Comte**
  - ☐ In 1992, Pierre Comte created a work called *Signature Terre,* which employed large black plastic sheets that could be viewed from the SPOT earth resource satellite. He hoped to create a "signature," viewable from great distances, that stated that the earth was inhabited by intelligent beings.
  - ☑ These works required the artists to understand enough about satellite imaging systems to devise a scheme that would be visible in the way desired.
  - ☐ They also required the poetry to imagine the view from a place where humans could not go before space technology.
  - ☐ Curiously, there are exceptions in world culture, such as the South American Indians described in *Chariots of the Gods,* who created earth works only visible from aerial per- spectives impossible with the technologies of their times.
- ☐ **Tom Van Sant—GeoSphere** **geosphere.com—**
  - ☐ *GeoSphere Project*. He has constructed a six-foot-diameter globe with an innovative projection system so one can see real-time, seamless composite images of the entire earth from multiple satellites.
  - ☐ Van Sant sees the globe serving educational, research, and commercial purposes.
  - ☐ The GeoSphere company offers to arrange, under contract, other kinds of projec- tions for particular purposes.
  - ☐ Significantly, art is rarely mentioned in the literature about the project. This omission highlights a dilemma in contemporary culture. Often innovative science and technology projects are not pitched as art even though con- ceptually they could be.
- ⊟ **Art Viewed from Earth**
  - ☑ Artists have also been intrigued by the converse arrangement. Several have devised plans for works that would be visible from the earth or even put into orbit.
  - ☐ These proposals have often been met with great resistance because of scientific, economic, and cultural issues.
  - ☐ **Pierre Comte** **www.pierre-comt**
  - ☐ Building on his idea of art viewed from the earth,
  - ☐ Pierre Comte developed the idea of *Dialogues with Space,* which also included art viewed from the earth. He called these ARTSAT (Art Satellite). In his 1987 article "Leonardo in Orbit:

Satellite Art,"[8] he re- counts his artistic research process, which sometimes required him to act like a scientist.

- ☐ Having used inflatables in earth installations, he designed an inflatable satellite and made drawings that he sent to the European Space Agency, which put him in touch with engineering firms. At each step the drawings were able to capture the imagination of officials and specialists, who then helped the project proceed.
- ☐ Comte had to learn technical and scientific information necessary to further the proj- ect. For example, launch limitations meant that anything bigger than ten meters had to be constructed in space, thus requiring an expensive and delicate procedure. Using inflatables mastered this dilemma. He also had to overcome other problems: "main- taining an inflatable structure in a vacuum and designing a guidance system for this ultra-lightweight engine." Working with technical advisers, he developed a proposal that worked through each of the problems.
- ☐ Although to me the idea now seems simple—to replace rigid, heavy constructions with inflatable, lightweight "masts"—no one to my knowledge had thought to do it. Perhaps it is because I am not a technician but an artist that the idea came to me. It is true that at the start I was not trying to realize an object that would be either logical or functional, based on solid technology. I simply tried to create an object that was beautiful with pure lines and dreamlike vocation: a star in the sky, but one born of human hands, a mad dream.[10]

- ☐ **Joe Davis, Arthur Woods, Jean-Marc Philippe, and Richard Clar**
  - ☐ The idea of monumental space art has intrigued several other artists. Some very ambi- tious projects have been proposed.
  - ☐ Artists' fascination with orbiting art as a symbol of
  - ☐ the unity of the earth is illustrated by projects such as Joe Davis's 1982 proposed *Ruby Falls,* an artificially induced aurora,
  - ☐ Arthur Woods's 1986 *OURS 2000,* a ring satel- lite one kilometer in diameter to celebrate the millennium (see Woods's "History" for more details).
  - ☐ Also to celebrate the millenium, Jean-Marc Philippe proposed *Celestial Wheel,* a forty-geostationary satellite wheel with the capability of laser activation from the earth.
  - ☐ Richard Clar's *Spaceflight Dolphin* unfolds a viewable dolphin sculpture out of the space shuttle.
- ⊟ **Scientific and Public Objections to Space Art** (p. 267)

- ☑ None of these projects has been realized.
- ☐ Many of them raised great resistance.
- ☐ Astronomers objected that bright sculptures in the sky would interfere with sensitive observations that must often measure extremely small variations in light.
- ☐ As a result, the International Astronomical Union, the International Academy of Astronautics, and the American As- tronomical Society all passed resolutions to prohibit orbiting space sculptures.
- ☐ Who do the heavens belong to?
- ☐ Space can be thought of as the ultimate public art project, complicated by jurisdictional confusion about international rights and unconventional activities. Are the treaties governing Antarctic and moon exploration good models? Is space art just another example of Western indus- trial hegemony usurping its prerogatives? Who has the right to impose its vision on humanity?
- ☐ Space art is useful because of this controversy. It forces the world to clarify its priori- ties. The technology makes possible the creation of works that can be viewed by enormous worldwide audiences.
- ☐ What activities are important enough to warrant placing objects in space?
- ☐ Evidently science, military, and commercial purposes are. But not all activities are.

- ⊟ **Art Executed in Space and Weightlessness** (p. 267)
  - ☐ Some artists have been intrigued by weightlessness. For the first time, space technology allows humans to free themselves from the full force of gravity.
  - ☐ It is fitting for artists to help explore the possibilities and implications of this phenomenon.
  - ☐ In some ways, traditional sculpture and dance can be considered poetries of gravity because of the way these works either emphasize the realities of gravity or attempt to defy it.
  - ☐ In 1984, Joseph McShane used microgravity in a materials coating experiment. Tak- ing advantage of NASA’s Getaway Special (the low-cost hitchhiking arrangement in which small experiments could be carried in spare shuttle space), he sent up a series of spheres that received coatings and were exhibited as art when returned to the earth.

- ☐ NASA came to accept "nonscientific" payloads but also upped the expense tremendously. Proving the "benefit" of art in expensive scientific contexts is a continuing problem inhibiting artistic experi- mentation. It is a wonder that any space art was ever executed.
- ⊟ **Arthur Woods's Cosmic Dancer** (p. 269) **www.cosmicdanc**
  - ☑ In 1993, Arthur Woods created the sculpture *Cosmic Dancer* explicitly for weightlessness.
  - ☐ It flew in the Mir spacecraft, and a video documentation was returned to the earth. The sculpture achieved its true form only once placed in weightlessness. The project was also undertaken to explore the impact of integrating sculpture into cosmonaut work and living spaces: What is the role of art in the special circumstances of isolation and distance from the earth?
  - ☐ Cosmonaut Alexander Polischuk has written reflections of his experience with *Cosmic Dancer*. He notes that art had an important calming effect in the high-stress situation of space and that it was a comforting reminder of the earth. He also described some of the specifics of experiencing weightless sculpture:
  - ☐ Letting go of the sculpture, it spins and spins until it reaches an obstacle. The gravity does not disturb it nor does it force it to stand still . . . The *Cosmic Dancer* is an incredible sculpture, angular and unusual for the classical understanding of art. Nevertheless, it made us pleasure. And that it is a "cosmic dancer," the English title says, we have never had any doubt. Particularly interesting was to dance with it to music. . . . It is interesting to watch the *Cosmic Dancer* against the portal in the background, but one has to decide whether to look at Earth or at it.

    Very interesting is the behavior of the construction and the surface of the sculpture when its angular shape touches a transparent media, such as a liquid substance . . . Here the behavior of a liquid and one of a solid material are easy to observe; they both possess a moment of inertia. The rotating movement of the water in front of our sculpture *Cosmic Dancer* is somehow perceived differently and is interesting, not only in view of the weightlessness, but also from an emotional and aesthetic viewpoint. Sometimes it behaves like a living being, it swings and floats . . . And contemplating the sculpture turning in weightlessness while listening to music results in an effect which is possibly totally unknown on Earth. It is difficult to describe this effect.[12]
- ☐ **Kitsou Dubois** (p. 269) **www.kitsouduboi**

www.youtube.c

- ☐ Kitsou Dubois is a choreographer interested in the phenomenon of the body's relation to gravity.
- ☐ Science is seen as a critical resource in this investigation.
- ☐ In the *Leonardo* article "Dance and Weightlessness," Dubois traces the influence of science on modern dance, noting two influences: the Japanese Butoh dance form, which grew out of the Hiroshima nuclear tragedy, and Merce Cunningham's thoughts about relativity. Cun- ningham found Einstein's notions of space liberating:
- ☐ I [Cunningham] decided to open up space, to consider it as a totality of equal value: thus, whether occupied by someone or not, no point is more important than any other. There is no need in such a context to refer to any specific point. Then I read one of Einstein's sentences: there is no fixed point in space. I said to myself: if there is no fixed point, then every point is both fluid and interesting.[13]
- ☐ Dubois is a choreographer who worked on expanding dance space through choreogra- phy in unusual places, experiments in new movements, and teaching diverse groups.
- ☐ this led to work with weightlessness at the French CNES (National Center for Spatial Studies) to explore sensory and movement training in microgravity via para- bolic flight routines instituted to simulate space flight.
- ☐ She describes the training program that has been developed, which helps both dancers and astronauts experience the body as a subjective experience.

- ⊟ **Other Artists and Projects**
  - ☑ ***Frank Pietronigro*** and collaborators at the San Francisco Art Institute proposed a series of "Microgravity Experiments" for NASA's weightlessness simulator that explored dance, performance, and media activities as a way of relieving microgravity stress.
  - ☐ ***Pierre Comte***'s *ALPHA of Zero G*. was a sculpture of three primary-color spheres that came to life in the zero gravity airbus training plane.

- ☐ **Painting and Photography Based on Space Exploration** (p. 271)
  - ☐ Many artists have been stimulated by the images being returned from space by video.
  - ☐ Fascinated and perplexed by what they saw and didn't see, they have painted and composited images of other worlds.

- ☐ Some artists extrap- olate carefully from the scientific information available and may even be involved in planetary science.
- ☐ Others let their imaginations roam free, using the data only as a distant jumping off place.

- ⊟ **Conceptual and Electronic Works** (p. 271)
  - ☑ Time, distance, and speed seem different in space than on the earth.
  - ☐ A satellite or a spacecraft can access points on the earth so much easier than the earthbound.
  - ☐ ability to communicate at these distances and speeds intrigues some artists.
  - ☐ Some projects have explored these phenomena via communication between the earth and cosmonauts. Other projects have reflected on the enormous physical and time horizon of extra solar system space.
  - ☐ How can artists respond to the overwhelming vastness of space and to the earth's place in such a cosmos?
  - ☐ Using microwaves, lasers, and radio waves, some artists have attempted to mark that vastness.
  - ⊟ **Michael Heivly** **www.csub.edu—**
    - ☑ Starting in 1979, Michael Heivly worked on a series of sculptures that translated terrain into sound events and microwave transmissions. www.csub.edu-
    - ☐ These transmissions were beamed at particular constellations, including Ursa Major and Draco, and would retain their form for millennia.
    - ☐ Heivly notes that tech- nology has helped alienate people from their physical surroundings, and he works to reestablish that relationship:
    - ☐ Unlike our ancestors who lived by the stars, very much connected to the changing earth for their physical and spiritual survival, we are no longer aware of our sequential relationship to the natural phenomena of the universe. We have moved away from our collective, mythological center. Alarm clocks wake us up before the sun. . . . All of this allows us to entirely ignore any relationship we might have with the natural world. How does this affect who and what we are and how we relate to our ancestors, to the earth itself, to the universe?[15]
  - ☑ **Arthur Woods**
    - ☑ Commenting on the fragility of life on the earth and the possible extraterrestrial origins of the earth's life, Arthur www.cosmicda

Woods's *Seeds* project proposes to purposely seed terrestrial life in other parts of the universe.

- ⊟ **Other Artists and Projects**
  - ☐ ***Vastness of the Universe***
    - ☐ French artist ***Jean-Marc Philippe,*** whose earlier project used a radio telescope to beam thousands of Minitel-collected messages into space, has pro- posed the "Keo" project, which will collect messages that people think are important enough to want to send them on a spaceship that will return to the earth fifty thousand years in the future.
    - ☐ ***Ezra Orion*** created a Milky Way "sculpture" by aiming a laser at selected points in the galaxy. Earlier, Orion had created a work that conceptualized plate tectonics as sculpture. He also proposed sculptures to be realized by the Mars Rover and other planetary probes.
  - ☐ ***Space Science and Astronomy***
    - ☐ The ***Arts Catalyst*** 1999 "Cosmic Chances" conference brought together astronomers, cosmologists, and artists to explore methods of knowing the universe, including presentations on topics such as SETI, solar wind, meteor capture, and solar neutrinos,
    - ☐ ***Marko Peljhan*** has made a proposal that the art research lab MAKROLAB become part of a network of scientific labs studying the phenomenon of Aurora Borealis.
  - ☐ ***Unified Visions of the Earth***
    - ☐ ***Clar***'s "Earth Star" project proposes to create a ceramic tile with soil from many conflict regions of the earth that will be fused on reentry.
    - ☐ Part of his "Quiet Axis" series, ***Lowry Burgess***'s space shuttle "nonscientific payload" work *Boundless Cubic Lunar Aperture* included holograms and cubes made from all of the elements known to science and water samples from all the world's rivers.
  - ☐ ***Earth-Based Works***
  - ☐ ***Charles Ross***'s *Star Axis* was a project to excavate a conical tunnel in the earth precisely pointed toward the star Polaris. At various places, a different circle of the sky would have been visible, indicating the expected orbit of Polaris; the year would have been marked on the wall. The cave would

have thus recorded the entire twenty-six-thousand-year orbit progression.

- ☐ *Nancy Holt* created a series of earth works that put viewers in touch with astronomical time frames and positions of stars and the sun. *Sun Tunnels* lines up shadows during the solstices. *Annual Ring* causes a shadow to fill a ring on the ground only on the summer solstice. *Dark Star Park* lines up shadows with poles only when the sun's current position matches its position on a day historically important to the town in which the work is placed.
- ☐ ***James Turrell***'s installations use light to create unusual spaces where light can look solid and make objects appear to float. His "Roden Crater" project is a long-term effort to transform the crater into a series of chambers linked to astronomical phenomena. Each chamber is designed to admit light from the sun, moon, and stars in certain ways and to create different light atmosphere.
- ☑ ***Pauline Oliveros***'s "Echoes from the Moon" (designed in collaboration with ***Scot Gresham-Lancaster***) uses radio telescopes and ham operators to bounce music and voices off the surface of the moon. It is an example of her interest in "deep listening," new ways of listening carefully to inner and outer sounds.

- ⊟ **Search for Extra Terrestrial Intelligence (SETI)** (p. 275)
  - ☑ Growing information about the universe has increased speculation about the possibility of other intelligent life.
  - ☐ Frank Drake devised his famous equation that calculated odds based on physical knowledge about star types and life histories, re- quirements to sustain life and evolution, and the probabilities of various occur- rences. The equation results in the conclusion of a very high probability that situations similar to that of the earth have occurred in many places in the universe, with the conse- quent evolution of intelligent life. Note that this high probability is based on the assump- tion of carbon life forms as we know them rather than allowing for unanticipated variations.
  - ☐ Researchers have theorized about the best methods for detecting life and communicat- ing with distant intelligences.
  - ☐ Others, however, consider the search as some of the most significant research under way.

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- ☐ What will it mean to establish the existence of other intelligences in the universe both spiritually and scientifically? What will they be like? What could we learn from them? What should be the nature of our communication with them? What kind of communication can bridge the possible gaps of time, experi- ence, and biology? What is worth saying? Who can speak for humankind? What should the decision process be like?
- ☐ The art and artifacts of the ancient cultures of the earth still speak to us despite being separated by thousands of years. When the *Voyager* spacecraft went out into deep space, images and sounds were included as impor- tant elements to speak to unknown civilizations should any encounter it.
- ☐ Leonardo Space Art Project has Web-published the position paper "A Decision Process for Examining the Possi- bility of Sending Communications to Extraterrestrial Civilizations," which was ap- proved by the International Academy of Astronautics (IAA) and by the board of directors of the International Institute of Space Law (IISL). The paper traces the evolution of SETI science, discusses the issues involved in humanity sending a mes- sage, and then describes principles for designing a process.
- ☐ *1*. The decision on whether or not to send a message to extraterrestrial intelligence should be made by an appropriate international body, broadly representative of Humankind.
- ☐ *2*. If a decision is made to send a message to extraterrestrial intelligence, it should be sent on behalf of all Humankind, rather than from individual States or groups.
- ☐ *3*. The content of such a message should be developed through an appropriate interna- tional process, reflecting a broad consensus. [17]
- ☐ Although there is not extensive activity in this field, some artists have begun to become involved in issues surrounding the detection of extraterrestrial intelligences and creating communication with them.
- ☐ More con- temporary interest is evidenced by the SETIathome project, to which thousands of peo- ple have subscribed to donate unused computer time on their home computer to help in the analysis of signals from space.
- ⊟ **Arts Catalyst—Searching** (p. 277)
  - ☑ Arts Catalyst undertook a project called *Searching,* which explores the SETI initiative from multiple perspectives. The

organization has funded open-ended collaborative proj- ects between artists and researchers working at institutions, such as Jodrell Bank and the SETI Institute, to investigate research tools such as radio telescopes and the Hubble space telescope.

- ☐ **Other Artists and Projects**
  - ☐ ***Lewis DeSoto***'s *Observa- tory* offered viewers a mix of sounds heard by SETI researchers during their searches while they watched a television tuned to snow, thought to be caused in part by random sky noise.
  - ☐ ***Douglas Vachoch*** has sought to use semiotic analysis to deter- mine the parameters necessary to create pictorial communication with extraterrestrial civilizations.[18]
  - ☐ [8] In its yearly series of conferences on Space Art, Leonardo's French affiliate ***OLATS*** (*Observatoire Leonardo des Arts et des Techno-Sciences*) sponsored a workshop on SETI which examined "the different 'searches for life,' their scientific basis and meth- odologies but also their myths and 'silent background,' from looking for 'ones-like-us' [intelligent life, with the SETI/Search for Extra-Terrestrial Intelligence activities] to 'ones-different-from-us' [astrobiology] who might even be based on a non-carbon-based- life."
  - ☐ San Francisco's ***Yerba Buena Center for the Arts*** sponsored a 2000 exhibit called "Above and Beyond" focused on UFOs and "science, belief, and understanding." *Michel Redolfi* created the Earthsounds project, which is soliciting people all over the globe to contribute sound samples "representing earth" to be included ultimately in attempts to contact extraterrestrial life.

- ⊟ **Art Critiques of Space Research** (p. 278)
  - ☑ As previously mentioned, not everyone is enthusiastic about space science or space art.
  - ☐ The worlds of mainstream and technology art have mostly ignored it.
  - ☐ Some social critics see space activities as a diversion from attention to more important issues on the earth and a continuation of "male," Western preoccupations with colonization and domina- tion.
  - ☐ **Steven Hartzog**

- ☐ U.S. artist Steven Hartzog explores the overselling of space and the ignoring of space travel's realities.
- ☐ Here is Hartzog's analysis of space program problems:
- ☐ **Summary: The Hopes** (p. 279)
  - ☐ Scientists and artists influenced by science are often more optimistic. They see great opportunities and significance in astronomy, cosmology, and space science. It is claimed that artists can have significant impact and that ignoring the importance of space research by our culture and the art world is blindness.
    - ☐ Arthur Woods expresses this opinion in his paper "Art and the New Millennium":
    - ☐ It may be said that the power of art to explore human experience has been outstripped by the wonders of science and technology in the past one hundred years, but the necessity of art to balance our understanding and emotions about the world we have created has never been greater than it is today.[20]

- ☐ **Notes:**
- ☐ Global Summary: (Rough Draft)
  - ☐ In the chapter of space it is clear that the interest is not only the phenomenological interest but also the implications to humanities vision of itself.
  - ☐ The interest in using the material of space, the philosophical implications of space are enabled by the art work that strives to overcome the limitations of this new scale. The awareness of this new condition that humanity has found through will of technology, is now grappling with the time scales and the mortality of the species. The planet has an end point and so does the universe, but the expression of using this domain / science is the rational means that artist and scientists have time to imagine a world that is fully integrated by the condition of weightlessness and not of gravity and air.
  - ☐ All fundamental understandings of space as well as virtual space is an instinctual condition that expresses the opportunity and the challenges that passing the threshold of a body that is oriented by forces is not bound in one direction. The multiple directions of all particles atoms and bits needs an understanding that the knowledge of scales and existence must be layered and focused on the awarenesses of all senses and forms of conciousness.
  - ☐

Trojan Horse, introduces values inimical to the basic qualities for which the artist strives. The very process of engaging the technology quite possibly undermines the qualities the work strives for. This situation demands the development of a 'critical technical practice' (Agre).

- ☐ This paper seeks to elaborate on this basic thesis. It is written from the perspective, not of the antagonistic luddite, but from that of a dedicated practitioner with twenty five years experience in the design and development of custom electronic and digital artworks.

- ☐ **Note and Disclaimer:**
- ☐ **Keywords:**
- ☐ **1. INTRODUCTION: (pg. 1)**
  - ☐ These theoretical inquiries arise out of pragmatic attempts to apply these technologies to artistic practice. I have been developing custom electronic and digital technologies for cultural practices for twenty-five years. Throughout that time, I have felt an abiding disquiet regarding implicit disjunctions between technological and cultural practices, at a fundamental level. This paper is an attempt to make explicit a set of issues which I feel are fundamental to the contemporary socio-technological context, and crucially relevant to questions interdisciplinarity, interdisciplinary digital arts practices, and to the question of the role of the arts on campuses and in the world at large [3].
  - ☐ The presence of arts practices on contemporary campuses is fraught with complexity. While contrasts are commonly drawn between the science and humanity 'sides' of campuses, these practices share a common commitment to abstraction, symbolic notation and some notion of the power of general applicability. The academy as a whole, is a culture of the symbolic notation, of the book and the text. The arts, at its core, bypasses this translation from worldly experience of materiality to symbolic representation as alphanumeric characters. The arts is largely concerned with the way objects, forms, materials, and bodily actions can *mean*. The arts focus on immediate sensorial experience, unmediated by alphanumeric translation. I make this generalization quite aware that it is full of holes, but I make it in order to set such practices in stark contrast to practices of alphanumeric abstraction, and specifically to the act of coding and the functioning of code as an alphanumeric machine.
  - ☐ This inquiry maps out a project of radically interdisciplinary intellectual research and artistic/technical production concerning the relation of embodied practices to the current state of digital technologies and the underlying values reified in the technology. As such it entails:
  - ☐ 1. a rigorously interdisciplinary agenda,

    2. a tightly integrated relation between theory and practice, where practice initiates theorising and theory informs practice,

    3. the recognition of the need for the development of a theory of practice and of the 'aesthetics of behavior'.
  - ☐ In my opinion, the full force of some of these

    realities is felt most clearly by the practitioner in the complex process of realisation of cultural artifacts employing these technologies. Contemporary digital arts practice is shaped, in large part, by the ramifications of the disjunctions discovered in a process where technological components formulated for instrumental ends are applied to goals which exceed these instrumental conceptions. Michael Mateas observed that 'you push against the materials and the materials push back'. But in the case of digital arts, one might well assert that it is the ideology pushing the materials back.

- ☐ These concerns can be differentiated into sub- categories. The most superficial (but nonetheless challenging), have to do with the pragmatics of the technical capabilities of these devices and the development of a design and development process for cultural applications which incorporates them. Another layer of concern is about how employment of these devices changes the kind of art which is made. Basic to any theoretico-historical study of emerging digital art practices is the recognition that such practices are the confluence of two streams. These are the traditions of industrial automation rooted in rationalist science (and consumer commodity economics); and the traditions of artisanal arts practices and their related institutions and philosophical contexts.
- ☐ Digital Cultural Practice is a heterogenous field, and distinctions can be drawn in along diverse axes. A fundamental distinction is between practices which are the emulation in digital technologies of pre- existing practices, as compared with those which are novel and 'native' to the new medium, for which one must struggle to find precedents in pre-digital practices. 2D image treatment rooted in photography, graphic design and painting, and digital video, are prime examples of the former. On the other hand are practices which are in some sense native to the context of computational technologies,opinion, the full force of some of these and could not exist via backwards-emulation: 3D modeling and animation, hypertextual and sensor based interaction, interactive and multi-player networked gaming. (While this distinction is fundamental, it is not always clear, and as practices evolve, these distinctions tend to become aspects) [4]. Any practices that exhibit dynamic real time behavior, or responsiveness to their environment and require real time computation and/or networking fall into the class of practices for which, I believe, a wholly new branch of aesthetics is demanded: the aesthetics of behavior.
- ☐ A deeper level of inquiry concerns the negotiation of the values of the professional culture which gave rise to the machine with respect to the values and traditions of the arts. What flows from this is a recognition of how the values of the discipline of engineering insinuate themselves into art practice and art consumption, changing the practice. At root, one is drawn into a deeply interdisciplinary consideration of the fundamental values and world-views of these two kinds of practice, these *two cultures*.[5]
- ☐ What is called for then, is a simultaneous assessment of these values ands their implications to contexts outside their 'native' territory, and simultaneously, a reassessment with respect to these issues, of the core values, methodologies and sensibilities of the arts. We need then, to find new, relevant and compelling argument for the arts in the new techno-social context. This will necessarily lead, I believe, to a re-evaluation and re-valuing of aspects of the traditions of the arts which have been or are in the process of being occluded or lost, due to the authority of technological rhetorics perceivable on every campus, a certain kind of cowering in the face of such rhetorics, and an *articulation deficit* on the part of arts practitioners.

- ⊟ **2. FRAMING THE ENFRAMING (pg. 3)**
  - ☑ *Embodied in the machine there is an idea of what the mind is and how it works. The idea is there because scientists who purport to understand cognition and intelligence put it there. No other teaching tool has ever*

brought intellectual baggage of so consequential a kind to it. Theordore Roszak. [6]

"..most tools produce effects on a wider world of which they are only a part, the computer contains its own worlds in miniature…" Paul Edwards [7]

A computer…does not simply have an instrumental use in a given site of practice; the computer is frequently about *that site in its very design. In this sense computing has been constituted as a kind of imperialism; it aims to reinvent virtually every other site of practice in its own image*. Philip Agre [8]

- ☐ Heidegger proposed that the essence of technology is a project of 'enframing'. We make the world amenable to manipulation and exploitation through instrumental science. We dominate nature through knowledge. The last few centuries can be characterised by an ever-growing assemblage of knowledge and power, science and technology, which enframes the world and ourselves within it. At issue is not whether instrumentality is a good thing, but whether the machinery, the hardware and software, is imbued with the ethos of instrumentality. And if, in applying this technology to human pursuits not previously embraced by such technology, these practice are thus perturbed in a way which might be deemed unfortunate.

- ☐ Technologies do not pop into the world fully formed, they emerge from specific cultures with specific traditions. In order to understand what the computer, at root, is, we must look at its history, its precedents, the goals set for the research, the interests of the funders, and the intellectual traditions of the generating contexts. The question then becomes: can we assume that the computer is a neutral tool, or does it inhere specific notions about information, knowledge, and representation (etc)? This would not be a huge issue if the technology remained located in its original application zones. But the contemporary socio-technological situation is one in which this technology is constantly moving out across society and culture, engaging various sort of established practices for which the instrumental paradigm (and related values) has dubious relevance. This then is a call for an active critical engagement. The following questions must be asked:
- ☐ 1. Are fundamental philosophical values reified in the technology. If so how and where, and how are they expressed.

  2. Are these values supportive or destructive of each of the new zone into which the technology moves.

  3. These questions then imply an assessment of the core values of the practices which are effected.

  4. If the result of the inquiry reveal areas of serious concern, then one must ask: is the situation salvageable, ie can the tools and the practices be adapted together to produce a positive situation. If not, must the entire project of technological art be abandoned or is it possible to imagine a technology which would have such positive qualities.

  5. If so, we must discuss how to build technologies which are more supportive of the core values of these practices. An entire

interdisciplinary technological research program is thus implied, one that moves towards technics from real human needs, rather than moving out from motivations of profit and manufacturing efficiencies, through advertising campaigns into the market.

- ☐ The Cartesianism of the academy and its emphasis on abstraction; the construction of Generality as a virtue in computer science (which is itself entirely in sympathy with the logic of economy of scale in industrial production); and the emergence of the digital commodity and its associated culture: these three form an unholy alliance which demands interrogation in the interests of more critically sound digital cultural practice. The rationalism of the academy is characterized by the valorization of symbolic forms of representation: textuality, logico- mathematical symbol systems, and symbolic representation more generally. Computer code is entirely consistent with this environment. (The paradox of code is that it implements and reifies academic textuality as an operational machine). Philip Agre makes a similar argument when he observes that these fields "concentrate on the aspects of representation that writing normally captures. As a result, theories will naturally tend to lean on distinctions that writing captures and not on the many distinctions that it doesn't." [9].

- ☐ When the values of computer science piggyback on commercial technologies as they travel out of one socio-cultural niche into another, they can cause havoc. The computer is, in this sense, a Trojan Horse which carries these ideas, hidden, through the gates. Agre describes the application domains of computational systems as a frontier: "Each of these borderlands is a complicated place: everyone who resides in them is, at different times, both an object and an agent of technical representation, both a novice and an expert...every resident of them is a translator between languages and worldviews: the formalisms of computing and the craft culture of the "application domain"". [10]

- ☐ We cannot dispute that computers and computation constitute the *paradigmatic technology* of our day. [11] As in Descartes' day, when human physiology was described in terms of the cogs and springs, so today, even thought is susceptible to computational metaphors. It is reasonable to be deeply suspicious of any theorisation that adopts such metaphors unreflexively. Yet, by the same token it is easy understand why computational explanations are unreflexively adopted: they are the intellectual waters we swim, they are a constitutive part of our world view. As a result, many fundamental qualities of our culture evidence a drift as a result of computation and computational ubiquity of metaphors.

- ☐ Take for instance the astonishing changes in the notion of *play* over the last couple of decades. When stripped of its colorful monsters and futuristic weapons, game-play in the paradigmatic first person shooter is indistinguishable from the worst qualities of industrialized labor: constrained and highly repetitive tasks executed in social isolation, a tight harnessing of user and machine, rewards linked to high rates of production, to say nothing of the covert inculcation of military skills. In this way, pleasure has been instrumentalised and commodified. Any gaming-partisan can (and several have) taken me to task, saying 'but game X is not like that', or 'such an analysis ignores aspects PQR which are culturally good'. It will also be asserted that such games are shaped by the market as well as by the makers who themselves are the product of a larger and older culture. I do not, in principle, dispute those objections, but the fact remains that, for better or worse, such game-play is colored and constrained by the history of industrial labor and the development of sciences of man-machine integration for military applications.

- ☐ To reiterate: the purpose of this paper is to explore dimensions of the fundamental problematic encountered when machines for abstract mathematico-logical procedures are interfaced with cultural practices whose first commitment is to the engineering of persuasive perceptual immediacy and affect, employing sensibilities and modalities alien to the technology and possibly incompatible with its structuring precepts. I must necessarily paint in broad strokes, in order to broadly describe a class of issues. Inevitably exceptions can be found. My concern is not so much to persuade as to make explicit a set of issues which must be engaged if critically coherent practice is to occur in the field. This paper is thus a call to a Critical Technical Practice in Digital Cultural Practices. I want to draw a distinction between Agre's use of his term and my use here. He called for such practice as a corrective for the difficulties he recognized in a discipline (AI) with a substantial history behind it. I want to argue that in digital arts, we need a critical technical practice in order to build a critical/theoretical apparatus adequate and appropriate to an emerging range of practices.

- ☐ This conversation, is, at root, concerned with the power of scientifico-technical rhetorics and their relevance to fields which have come to be on their margins, whether that is because of an imperializing on the parts of those discourses, or due to their attractive power to previously non-scientifico- technical fields in the current technophilic climate. (I do not mean to universalize regarding scientific practice, there are many 'sciences'. I refer to the power of the those discourses as presented in their oversimplified form for ideological or commercial purposes.) As Friedrich Kittler noted, following Nietchze, *"If the 19th century…was a victory of the scientific method over science, then our century will be one which saw the victory of scientific technology over science*." [12]

- ☐ There could be little argument that the computer is the most complex appliance in common use at home and in the workplace, so any discussion of its use must be general, or must differentiate between diverse aspects: the interface, the operating system, various applications, the fundamental procedures which define the von Neumann machine, theoretical paradigms, the status of the device in contemporary cultures and in the past, the various modes of use, as research tool, as office tool, as pleasure tool, the integration of the machine into a global network and all the dimensions of networked computer use. To address all these aspects would exceed by far the time and space available here. Here I focus mainly on the history, cultural placement, computational fundamentals and the interface.

- ☐ **3. ACADEMIC CARTESIANISM AND ARTISANAL CRAFT (pg. 5)**
  - ☐ *All the art projects I have worked on have at least one thing in common… From an engineers' point of view, they are ridiculous*. Billy Klüver
  - ☐ There is, in the western academy and other aspects of western culture, a deep value which ascribes greater worth to more abstract and 'mental' work, and implicitly or explicitly denigrates work which involves manual labor and skill, and therefore devalues the people who do that work. This is a dangerous and foolish belief system. Manual work is not inherently stupid, an where it is, it has been made that way through the de-skilling of labor in industrial contexts, and prior to that in the proto- industrial context of slave labor driven Carribean sugar plantations. [13] It is necessary to distinguish between aggressively de-skilled industrial labor, and artisanal labor. Technical labor, crafts and trades, bodily training in sports, dance and martial arts, often require high intelligence (think of virtuoso musicianship). Intelligence and manual skills are not mutually opposed.
  - ☐ Computer science, as a technical discipline, reifies philosophical notions which, oddly, were already under interrogation in other disciplines prior to its formation. Among these are the Cartersian dualism, an implicit and unproblematised Objectivism and a simplistic notion of Intelligence, inflected by a paranoid militarism. The conception of intelligence in computational discourses is rooted in an early-mid C2Oth approach valorizing mathematico-symbolic problem solving – precisely the same functions that the first generation of AI researchers sought to simulate in their systems (famously Newell, Simon and Shaw's Logic Theorist). This monolithic conception of intelligence has been largely abandoned by the psychological community, replaced with an idea of intelligence as individually varying aptitudes in 20 or more aspects. It is surprising is that mathematical logic should be unilaterally hailed as the hallmark and epitome of intelligence in humans, and yet the process is utterly consistent with a logic of isomorphism (Maslow) ubiquitous in computer science. Boolean logical operations are implemented as a machine – then the machine demonstrates (via applications such as Logic Theorist) that human intelligence is logico- mathematical in nature. Here then is a prime example of the representational nature of computer science, in which an automated system is built to emulate a certain description of a human capacity, and this system and the rhetoric around it then goes on to form an entire school of thought about human thinking – computationalist cognitive science.
  - ☐ This issue is of great significance in the current discussion, as the kinds of intelligences which enable the arts and cultural practices are among those exclude from the mathematico-symbolic conception. Handwork can involve high intelligence and sensibility. But that kind of intelligence – embodied, kinesthetic and multi-modally sensorial intelligence, tends to be irreconcilable with textual, alphanumeric logico-symbolic forms of work. Contrarily, the process of translation from the abstract to the concrete is an exercise of high intelligence, and valuable knowledge and insight is drawn from actual manipulation of matter, as opposed to talking about it or using pre-constructed simulations.
  - ☐ Conventionally, artists are 'not very clever but they are good with their hands'. The implication is that artists are stupid, but it also reinforces the mode of bastardized Cartesianism which infects our campuses that asserts that manipulating matter and intelligent thought are mutually exclusive. [14] An

artist must have a deep sensitivity their tools and their medium. There is a tension between the academicism required of the university, and the traditions of bodily training and kinesthetic and proprioceptive sensitivity development so crucial to virtuosity. As programmable technologies have become increasingly usable, coding as a practice has become increasingly pervasive and basic mechanical and electronic skills have seemed less relevant. In many fields, computer technology is causing a problematic drift away from embodied and material intelligences. [15]

- ☐ To a generation naturalized to commodity digital technologies since childhood, three related assumptions seem to qualify their relation with that technology: an assumption that all possible digital commodities already exist; that they are value- neutral; and that all that is required in making a project is to plug them together and provide necessary software glue. None of these could be further from the truth. All commodity technologies come with constraints as well as affordances. These constraints are often only revealed in the process of working with them and attempting to make them do something they were not designed explicitly to do. Poor choice of high level components can make tasks more complex and more difficult than necessary. Such reality is consistent with the general principles of knowledge representation, indeed, such artifacts embody and reify certain modes of knowledge representation.

- ☐ The notion of information having the possibility of existing in a disembodied form is, we must remind ourselves, axiomatic and rhetorical and without evidence. All information is materially instantiated, and the idea that information can be migrated from one material to another does not assert the independent immaterial existence of information as a thing. The entire computational dualism of immaterial information inhabiting a material substrate is nothing but a recapitulation of Descartes' peculiar and tenuous dualism, conjured up to resolve his own crisis concerning the relation between the immaterial soul and the material body. It is odd that computer science would take as so fundamentally formative an hypothesis that has not a shred of scientific evidence to support it.

- ☐ Contrary to the idea from symbolic AI that 'intelligence' was the logical manipulation of symbolic tokens in an abstract reasoning space unconnected to the world, it is equally easily asserted that interaction with the physical and social world constitutes intelligence, and that historically, AI took its position because the necessary sensing and interpretation tasks were technically challenging, if not intractable. (see 'the matter with matter', below).

- ⊟ **4. MAN-MACHINE INTERACTION AND TECHNOPHILE RHETORICS OF LIBERATION (pg. 7)**
  - ☑ *"Our computers retain traces of earlier technologies, from telephones and mechanical analogs to directorscopes and tracking to radars."* David Mindell [16]
  - ☐ As David Mindell reminds us, the physical conformation and functionality of the machine we use is determined by the history of technologies from which it arose. It is a skeuemorphic assemblage. The history is military, bureaucratic

and commercial, to varying degrees (depending on who you read). Interactive multimedia, we must recall, is the child of Cold War computing research. The ur- HCI project was the SAGE system, which put soldiers with keyboards and lightpens in front of monitors, to accomplish the complex pattern recognition functions which the system could not autonomously manage. This constellation of technologies was the model for the keyboard-mouse- monitor paradigm. The fact that this harnessing of flesh to machine was later clad in the rhetoric of liberation in the heyday of interactive multimedia remains deeply ironic.

- ☐ Why do I sit at a desk to use a computer? The unavoidably historical answer is that the device was developed as a replacement for a component of a preexisting organisational and architectural order, in this case the business office. The desktop computer is, or was, an enhanced typewriter and calculator with added filing-cabinet functionality. It follows then that it is particularly useful and relevant for activities which resemble office desk activities, and is decreasingly appropriate for activities whose social and architectural placement diverges from that scenario. Most cultural and artmaking activities do not resemble office work in their physical contexts, methodologies or goals.
- ☐ While various pioneers in computer art have been and are being inserted into a retroactively compiled pre-history of the field, the fact remains that in the formulation of the fundamental aspects of the machine, hardware and software, and their relationship, serial processing and operating systems, networking and interface, artistic needs, goals and methods were never considered and no artist was ever consulted. It seems surprising from this perspective that any artist would imagine that computer art might be possible. (That, I suppose, is the genius of art.) By the same token, it is no surprise that in attempting to utilize the machines, artists have experienced repeated frustrations. (In the past I have likened the situation to sending a swat- team into battle with excellent hair-dryers and toaster-ovens.) And seldom does this frustration reach a level of analysis where a distinction can be made between a technical fault (a bug) and a limitation in principle.
- ☐ There is no end to the accolades we hear offered for the triumphs of computer animation, or scientific visualization, or hypertext, or the web, or multiuser gaming- new cultural practices which are more or less compatible with the various constraints of conventional computing and computer use. It is much more difficult to ask – if the basic conformation of the device and its peripherals were different, what kinds of socio-cultural practices might be accommodated, assisted or afforded? This very acceptance of the hardware conformation of the machine constrains the kind of practices which can occur. Here then is a research agenda which begins from rigorous intellectual inquiry and offers the prospect of unimagined realms of technical and aesthetic development.

- ☐ **5. EMBODIED AND SITUATED PRACTICES AND THE DRIVE TO FORMAL ABSTRACTION (pg. 7)**
  - ☐ As a longtime practitioner of practices of embodied intelligence, I remain alarmed that we are prepared to accept as generally useful, a machine system which is only capable of interpreting as input, linear strings of alphanumeric characters. The machine knows nothing of the world, except that which a human predigests and feeds to the machine as alphanumeric strings. Such a system is excellent for doing arithmetic and accountancy, calculating tide and

firing tables, storing and retrieving textual records (the kinds of practices which the technology was originally designed for) because these practices have already been abstracted into formal mathematico-logical representations and organizational and cataloging systems generations before the machine existed. (Implementation of algorithms for sorting by date an alphabetically clearly depend on the prior development of calendars and alphabets, and the construction of a more or less universal literacy with regard to them.) Indeed, the machine is well attuned to these practices because the formalisms upon which the machine is based, and the formalisation of those organizational practices arise from a common root.

- ☐ The implementation of Boolean logic as electronic machine was the foundation upon which programs like logic theorist ran. So it should be no surprise them that such technology was found to be highly amenable to the automation of mathematical logic, and by the same token, it explains why problems outside that realm have been found so intractable.
- ☐ Rhetorics of computing, both marketing rhetorics and the more complex and subtle charactisations of the computational in literature and film, commonly contain extropian and anti-corporeal sentiments which imply that human experiences which are not amenable to serial Boolean logical expression are somehow irrelevant.Surely this should be an issue of greatest concern to practitioners and theorists of embodied practices, yet there is an almost entire absence of informed critical assessment of the relevance of such a technological paradigm to activities like, for instance, choreography, painting, cooking, sailing, clinical diagnosis or physical therapy.

- ☐ At root, this is the danger of the implicit acceptance of the von Neumann machine as the paradigmatic technology of our day as is the case in computationalist cognitive science. By taking the functioning of the serial processing Boolean computer as an acceptable analogy to the functioning of mind, we thereby afford the development of a specific range of ideas and research programs and close off the possibility of many others. There is thus, an underlying and seldom acknowledged conflict between the values reified in the hardware and software of computer technology, and the purposes to which these technologies are put. The simple fact is that media arts employ technologies designed for instrumental purposes – automation, accountancy, archiving. It cannot be asserted that artistic needs and purposes were ever considered in the design of the basic technologies. It follows then that existing computer technologies are unlikely to be optimally appropriate for such applications. This is unlike, for example, the evolution of the medium of oil paint, which was developed over generations specifically for the task of painting pictures.

- ☐ A machine designed for manipulating strings of alphanumeric characters may simply not be relevant to certain human tasks – why should we assume it should be? Why should we be at such pains to deny the obvious fact that our intelligence and our embodiment are precisely attuned to each other, through childhood development as well as through evolutionary process? Our intelligence is expressed in all modes and all combinations of modes of our lived physical being. Yet we are increasingly naturalized to the idea that we should be ready to translate any sort of human notion or practice, into keystrokes, in order to make in acceptable to this cloth-eared device. Not only is it absurd that such an expectation be attached to such a purportedly marvelous technology, but it relegates any human quality not amenable to such processing to oblivion or irrelevance.

- ☐ All too often, digital culture workers seem to think in terms of ‘how can I (change my behavior in order to) exploit this (available, commodified) technology’. This assumes that the currently available range of commodified hardware products are adequate and sufficient. I find this preposterous. Vast new areas of research and practice will open up if we instead ask: ‘what sort of technology would be an asset in the prosecution of my chosen task?’

- ☐ We are conditioned to imagine that the output (and input) of an interactive system will be symbolic, textual and graphical, probably on a monitor: a technologically arbitrary arrangement determined only by historical factors. Even though the hegemony of the desktop appears to be fissuring, the new portable, locative and wearable technologies generally simply minaturise and otherwise replicate this paradigm, as was the case for many of the interfaces developed for immersive stereoscopic environments (VR) in the 90’s: devices such as the ‘wand’ which absurdly ported the pointing device with buttons idea, originated to compensate for the lack of spatiality and tangibility of the desktop, into the realm of embodied interaction.
- ☐ The machine which has *trickled down* to artists is a machine for the quasi-arithmetic manipulation of abstract alpha-numeric symbols. [19] It is very good at that. But if digital arts practices are to develop in a well theorized way, we must ask: is art practice, always, primarily or ever, about the logical manipulation of symbolic entities? Indeed, to ask this question would be to open a range of important inquiries. Occasionally, exploratory work in the media arts explores the range of possible practices less constrained by paradigms of data-entry and command-and-control. It is worth noting that while such practices were more common in mid twentieth century art +technology experimentation, they were less common in late twentieth century work, after the consolidation of the desktop computer paradigm. It may be that such projects are now more confounding to audiences due to the naturalization of that audience to the desktop and related paradigms.

- ⊟ **6. ART AND AI (pg. 9)**
  - ☑ Art and AI are remarkable foils for each other. While AI saw logical problem solving as the defining pinnacle of intelligence, that capacity does not rank high in any conception of intelligence in the arts. Whereas AI came to grief in the complexity of everyday life, art would come to grief in attempting logical generalism. While CS takes generality as a virtue, one might propose that Art takes specificity as a virtue. While reductivism is part of the very fabric of CS, art is holistic. Artificial Intelligence found its initial successes in the automated solution of mathematico-logical problem solving activities, the logic theorist and GPS of Newell, Simon and Shaw, chess programs, toy and micro-worlds and the like. These were heralded as heights of intellectual achievement but they were consistent and constrained, local logical domains. AI stumbled on the realities Kurt Goedel articulated, as it attempted to extrapolate these successes to the real world, spoken language and the like: untidy, heterogenous and illogical domains in which artist are trained to operate.
  - ☐ The drive toward abstraction and generality came into computer science from the mathematical side. Abstraction is beguiling in its promise of transcendent

clarity. Abstraction affords a certain kind of power, yet it also forgoes any power that specifity and the particular can bring. As Wendy Chun notes, "Programming languages inscribe the absence of both the programmer and the machine in its so-called writing." [20]. Indeed the march to ever 'higher level' languages creates increasing abstraction in which both hardware specifics and stored data are increasingly effaced. Instrumentality entered from another side, linked to digital technologies as they arose as a form of industrial production. Against these, as it were, are arrayed situated and embodied sensibilities native to the arts, and a commitment to material specificities.

- ☐ In the histories of the plastic arts, in the modernist period, there was a notion that the appearance of an artifact should betray the nature of its materials and methods of manufacture. Hence the Bauhaus dicta of 'form follows function' and 'truth to materials'. Computing, contrarily, hews to a postmodern aesthetic of surface and superficiality: the function of the interface is to obscure the true nature of the machine. To protect the machine from the user and/or vice versa is the motivation of HCI.
- ☐ In terms of effective HCI, a tool or package is successful to the degree that it is intuitive. That is, that it recedes from conscious awareness, that it facilitates an illusion that there is no mediating technology between the user and the work object or process. Contrarily, that an artwork should contrive to obscure its own artifice is almost unconscionable in the modern and postmodern periods. Works often exist to bring to attention the artifice of the medium, the qualities of the technology or the way they perturb the situation or object of attention. Illusionism is constructed only to be broken, or intentionally problematised. In these terms, the relationship of (naïve) HCI and (critical) media art practice are entirely opposed. If HCI aspires to be 'ready to hand', media art aspires to be 'present at hand'. *In my own work Fugitive, an illusion of immersion was facilitated, only to be abruptly disrupted, in an attempt to bring the user to an awareness of their own trajectory of embodiment (as opposed to their subject position as an actor of limited agency in a prestructured world) and their own willing suspension of disbelief*. The function of the project, then was intentionally reflexive and 'meta' . It was conceived, as most of my works are, as an intervention into a discourse, in the form of an artifactual system which is directly experienced rather than read.
- ☐ A significant difference between computer science research and media arts practice lies in the ontological status of the artifact. As discussed above, for an artwork, the effectiveness of the immediate sensorial effect of the artifact is the primary criterion for success. It is engaging, it is communicative, it is taken to be coherent, or it is a failure. The criterion for success is performative. Most if not all effort is focused on the persuasiveness of the experience. Backstage may be a mess, a kluge. In computer science the situation is reversed. If the physical presentation is a little rough around the edges, or even missing entire pieces, this can be overlooked with a little handwaving, because the artifact functions as a 'proof of concept' which points to the real work, which is inherently abstract and theoretical.

- ☐ **7. INFORMATION, COMMUNICATION, MEANING (pg. 10)**
  - ☐ Fundamental to CS is the idea of information, and the idea that information exists, or can exist, in some abstract non-material realm, separate from and

independent of, its material substrate. This is an (inherently Cartesian) assertion and not a self evident truth. As a structuring assumption it is ripe for critique. As such, it has permitted the sorts of advances compatible with the paradigm, but, equally, has excluded entire avenues of research.

- ☐ Due to the elaboration of this paradigm, an ontological drift in the term ‘information’ has occurred over the past half-century under the influence of the development of techniques which utilize Boolean operations in a von Neumann architectures. Expressions such as Information Economy and new disciplines such as Informatics attest to this drift. The range of common contemporary uses of the term indicate, that, like many expressions in common language in which technical definitions and uses have been applied applied to them retroactively, the word possesses a hazy cloud of meanings. I suggest that the discipline is structured by an informal working definition which is not unproblematic because it confuses ‘information’ with ‘computability’. ‘Information’ has been formalized as quantifiable and logically manipulable (Shannon), and hence, *information* which is not quantifiable and logically manipulable is no longer information. Now it may be that it is not logically manipulable because there has been no compelling (commercial) reason to render it manipulable, or it may be that it is inherently not amenable to logic or quantification in that sense. We must therefore examine the value structure thus created: if logical manipulability is valorized, then vast realms of human practices are hence devalorised. [21].

- ☐ As Ronald Day notes: “Within the context of information theory’s operational and statistical understanding of language and affect, all human actions are subject to statistical and predictive prediction and design. Needless to say, such prescriptions have dire consequences for any statistically marginal dialects, forms, genres, or identities that are not socially dominant, as well as for activities of language (such a poetry, art, and even, sometimes, critical theory) in which language’s formal and social functions precede and ground their more, so called, “communicational” functions.” The conduit metaphor “ not so much plays the role of describing an empirical event, but rather, of transmitting and prescribing a certain model of language and society. That model is an utopian one of a formally closed communicational society, similar to that which is found in the “closed world” of the Cold War (see Edwards, 1996).” [22]
- ☐ In effect, these operational and statistical understandings construct a hegemonistic order which changes a landscape of plurality and diversity into an oppressive order, marking certain practices as deviant and forcing them underground.

  Interestingly, it is into this subterranean well that mainstream culture then dips for novelty. One way to understand the artistic avant-garde is as the provider of this mechanism to reintroduce (memetic?) variety from the cultural ‘wilderness park’ or ‘biodiversity preserve’ which is thereby constructed – a protected zone of (named and tolerated) deviant behavior which is simultaneously nurtured and marginalized. The mechanisms of the art world – small semi-commercial galleries and performance venues, small presses, low budget media production, and marginal public media (ie pacifica) provide the ‘conduit’ by which this diversity is sucked back into mainstream culture in metered doses to revivify it. [23]

- ⊟ **8. OBJECTIVITY AND ENACTION (pg. 11)**
  - ☑ One of the large trends in western thought over the last century, felt equally in the sciences, in the humanities and the arts, has been the challenges to the presumed authority, validity or even possibility of objective knowledge or a detached objective viewpoint. This trend is perceived in the crisis Heisenberg and Schroedinger brought to modern physics as it is in the problematising of authorial status and the authority of texts (Barthes, Derrida etc). In the sixties and seventies, both second-order cybernetic theory and autopoietic theory addressed the condition of the observer directly. As Heinz von Foerster remarked "Objectivity is a subject's delusion that observing can be done without him." The culture around computer science, like any other academic discipline, has its inconsistencies and oddities. These include subscription to an unreconstructed Cartesianism and unreconstructed Objectivism, explicit in the 'gods eye view' often encountered in software and systems. [24]
  - ☐ Enactive and situated theories of cognition and phenomenological critique of AI (Dreyfus, Suchman, Varela, Lakoff and Johnson, et al) exposed a platonic and top down spirit in that enterprise and the school of cognitive science associated with it, and led to a recognition of the relevance of theories of situated and embodied cognition. This opened a way for more subjective and less autocratic modes of technical practice (Brooks, Maes, Agre, Horswill and Chapman et al). David Marr begins his well-known 1982 book on vision with the statement that "vision is the process of discovering from images what is present in the world, and where it is". [25] But in human and animal biology, the study of perception as a one way process, an of methods in which are clinically isolated from lived experience has given way to the conceptualization of *active sensing*, which asserts the importance of examining the kinesthetically engaged, temporal coupling of sensing and action.
  - ☐ In the plastic arts we see an ongoing challenge to the single, detached, privileged viewpoint reified in perspective, first in modernist image making (Cubism) in which the conventional perspectival view was perturbed and multiple viewpoints were combined, thereby problematising the unique and authoritative viewpoint of the observer. By the mid 60's, the authority/ authoriality of the artist was actively under critique by artists themselves, as was the divide between critic and artist, and between text and the plastic arts (Conceptual art). This process generated a profusion of new genres in which the reliable stasis and formal relationship between viewer and work, as well as between artist and work, were broken down. In such cases the spatial and temporal subjectivity of experience was emphasized. Such works were thus often disorienting to their audiences.one can view the radical work of the 60s and 70s as prefiguring and modeling the challenges of digitally based art forms. (This would be consistent with the idea that one of the functions of art in our culture is as a cultural 'early warning system'.) With the availability of computational tools, the arts have engaged in the design of (automated) behavior and interaction. Recognition of this paradigm shift demands the abandonment of old aesthetics of passive contemplation and calls for the formation of an aesthetics of dynamic engagement by and with cultural artifacts [26]. This trend gives rise to modes of cultural practice in which the user takes some active and constructive role in the creation of her experience. This trend is clear in the transition from the authority of the cinematic eye/ screen to the distributed contingencies of multi-user gaming in hybrid

environments combining the agencies of remote players and semi-autonomous software agents or 'bots'.

- ☐ As I have previously observed, the theoretical agendas of (at least the first generation of) media artists were established in this period. In hindsight, one can view the radical work of the 60s and 70s as prefiguring and modeling the challenges of digitally based art forms. (This would be consistent with the idea that one of the functions of art in our culture is as a cultural 'early warning system'.) With the availability of computational tools, the arts have engaged in the design of (automated) behavior and interaction. Recognition of this paradigm shift demands the abandonment of old aesthetics of passive contemplation and calls for the formation of an aesthetics of dynamic engagement by and with cultural artifacts [26]. This trend gives rise to modes of cultural practice in which the user takes some active and constructive role in the creation of her experience. This trend is clear in the transition from the authority of the cinematic eye/screen to the distributed contingencies of multi-user gaming in hybrid environments combining the agencies of remote players and semi-autonomous software agents or 'bots'.
- ☐ As instrumentality is natural to the realm of machines, so autopoeisis and symbiotic relationships are natural to biological organisms and systems thereof. In biological (as well as social) systems, cybernetics notwithstanding, identification of discrete inputs and outputs depends on a tenuous and strained contrivance. A critically motivated practice might work towards technological projects in which organization is based on an autopoietic or ecological metaphor, where none of the entities or parts produce 'output' but, in the spirit of Actor Network Theory, all entities – humans, animals, instruments, networks and institutions are conceived as agents are linked in a hybrid, heterogenous and mutually enhancing circulation. New paradigms for understanding and making interactive cultural pursuits may be theoretically enhanced by reference to contemporary Cognitive Science, Neurophysiology, Ecology and Social Theory.

- ☐ **9. GENERALITY AND SPECIFICITY (pg. 12)**
  - ☐ A fundamental commitment of computer science is that of the *General Purpose Machine*. From the outset, generality was taken to be desirable, for reasons which are unassailable in formal terms. The principle of the 'general purpose machine', is an elaboration of Alan Turing's fundamental notion of the 'Universal Machine' (known latterly as the Turing Machine). The virtue of generality was reinforced with the GPS (General Problem Solver) of Newell, Simon and Shaw. It is basic to the concept of the digital computer, (this is textbook computer science history). The unquestioned axiomatic acceptance of the concept of generality as being a virtue in computational practice demands interrogation, especially when that axiomatic assumption is unquestioningly applied in realms where it may not be relevant. Indeed, the fact that the idea of the universal relevance and validity of the concept of generality is rarely asked; itself suggests fertile ground for interrogation. [27]
  - ☐ Historically one can identify a two-stage process of elision and reification, related to the economic principles of the computer industry and the rapid uptake of the computer in diverse socio-cultural contexts far from the original applications of the machine. The first stage was the transfer of the notion of 'general purpose' to the beige colored box and its big vacuum tube appendage. Quite possibly a result of the odd combination of ignorance,

mendacity and pecuniary interest so particularly characteristic of the advertising (so-called) industry. The idea of generality, entirely substantiable in formal mathematical terms, became thus attached to a physical commodity. The notion of generality thus offered justification for highly profitable strategies of consumer commodity economics. The casualties of this capitalist sortie are seldom discussed. But if all uses for the computer could be contained by alpha-numeric desk-work, the other sorts of human practices which were not compatible with that particular work culture, or not identified as profitable enough sectors to justify the investment in software tool development; had to reshape themselves or suffer the stigma of remaining uncomputerised.

- ☐ The world was thus divided into the computerized and non-computerised realms, and caché and advantages flowed to the computerized practices, in popular culture, which was itself increasingly defined by and located in digital practices; as in the academic and research worlds, where computerized/computerizable disciplines were able to access comparatively huge funds (much of which flowed directly back to the computer hardware and software industry). The result of this trend was that all sorts of human practices for which the computer, as formulated by the industry, was not ideally conformed, often then bent and reconfigured themselves to adapt, often at a significant cost to the integrity of the practice and its sensibilities and knowledge base.
- ☐ This process is observable in diverse fields and disciplines over the last quarter of the C20th, from engineering to the arts, but it is in the arts that such trends are particularly stark. This is because, as argued, the arts the practices rest on such profoundly different foundations, both historically and theoretically. This then is the core of my argument. Artworks are made by individuals of particular physical conformations, with particular perceptual and physical skills, immersed in specific cultural and historical contexts.

- ⊟ **10. EMBODIMENT, SITUATION AND TOOLS (pg. 13)**
  - ☑ *Pataphysics will be, above all, the science of the particular, despite the common opinion that the only science is that of the general*. Alfred Jarry, [28]
  - ☐ Tools are specific to functions. There is no such thing as a general purpose tool. Every craft has a range of specialised tools. The skilled craftsman is highly discerning about matching a task to a tool. The notion that generality is a virtue is opposed to a generally accepted notion that there is a tool for every job and a job for every tool. Contrarily, informed by the dual evil motivations of user- friendliness and generality – software tools seek to reduce the diversity and specificity of individual and cultural motivations and world-views: user friendly software tools make easy (generalisable) tasks easier and difficult (more specific) tasks more difficult.
  - ☐ In opposition to the ideology of generality, one might propose that art is naturally Pataphysical. An artwork is deemed to be excellent if it addresses a particular situation with persuasive precision. That is, by a subtle combination of the signifying potential of spatial organisation, materials, sounds, images and user dynamics; a coherent experience is generated which leads the audience/user into a particular realm of interpretation. An artwork is successful to the extent that it is specific. Generality is not a virtue in the Arts. Generality and affective power seem to be mutually exclusive. It's hard to imagine what a general purpose artwork would be like, unless it was one of

those generic and vacuous hotel room pictures, whose work is to proclaim a respect for art on behalf of their owners, while safely avoiding the danger inherent in actually being art. This is the fatuous conundrum at the root of the myriad of techno-cultural projects which attend to and intend to automatically generate cultural artifacts. The notion of the general purpose machine has indisputable power and relevance in its place. But we must be wary of the drift of axiomatic assumptions which can flow from a paradigmatic technology of both rhetorical and economic power.

- ☐ The interface and tools used some of the language of painting, but the actual physical interfaced was utterly unlike the performative context of the painter: the display was small and of low resolution, the complexity and subtlety of physical skill was completely absent, and the ‘output’ product was (usually) of small scale. How neatly the rhetorical power of the paradigm of disembodied information dispatched the unnecessary and encumbering bodily knowledge and liberated the abstract and pure idea content of the practice. In the face of six hundred years of refinement, the desktop computer painting emulator had barely sixteen. The technology did, and does, afford all sorts of capabilities which painting did not: actions could be reversed, multiple versions could be kept, product could be sent over network to a remote location – all remarkable and wonderful qualities. But, like the tea produced by the nutri-matic machine, it was almost entirely unlike painting. [29] It is strange to observe that amongst practitioners, teachers and theorist in such contexts (and there are many, not just with respect to painting but to a wide range of other skilled professions), critical assessment of the value and quality of the traditional practices vis a vis the new technologies is rare. Ironically, software developers are more likely to undertake a study of the traditional practices than are the purported guardians and partisans of the practice likely to undertake a study of software tools.

- ☐ **11. THE MIDI INSTRUMENT: PERILS OF GENERALITY (pg. 14)**
  - ☐ Electronic music interfaces tend to hew to two different paradigms. Some adapt or augment an existing instrument. This approach exploits the richness and specificity of the sensibility developed by the musician to the artifact. In musical performance, the bodily/artifactual cultures of virtuosity compare to similar practices in the visual and plastic arts, and each can be read in terms of interface and interaction design. Here one might consider the assumptions underlying in the term ‘interface’. For, as the face is conceived as the sensory front end of the brain, as the windscreen through which the driver of the bodily bus peers, so the notion endorses an archaic notion of perception a one-way sensory information flow into the brain, and simultaneously denies any reality to an ‘interbody’. [30]

  - ☐ Traditionally, the facility of the musicians bodily skill with his instrument is regarded as a measure of virtuosity. The sensitivity and specificity of the bodily actions of the musician is integrated, by dint of long training, with the trained ear and the mental characterization of acoustic quality. This is truly embodied interaction in a most refined and virtuosic sense. The alternate scenario is that of the patchable multi-function electronic musical instrument interface device. Such devices are, in HCI terminology, ‘controllers’ [31]. They afford the performer the possibility of mapping any variable of the computer music system to any perturbable aspect of the device. Such devices therefore import the 'virtue' of 'mappability' or 'assignability' from the purportedly 'general purpose' physical incarnation of the general purpose machine across to the musical instrument. But the musical instrument is a paradigmatic example of the specificity of tools argument. What makes a Stradivarius much more of a violin than a cigar box with a rubber band stretched over it? A history of increasingly refined atunement between the material specificities of the artifact and the embodied intelligences and skills of the player.

- ☐ The special quality of any instrument is, it would seem to me, its integration with a long standing culture of training and playing, and these things combined permit the subtlety of virtuosity. When played by a trained player, subtle and complex effects are produced. Specific kinds of modulation are associated with specific kinds of physical actions in specific locations on the instrument. The multi-function electronic musical instrument forgoes such possibilities. The range of possible variables can be void of common qualities. The same manipulation might address amplitude, or key, or access different samples on the hard drive. The assignment of any control function to any input sensor, and thus to any bodily modality, is variable and arbitrary. With such flexibility and diversity, a fluent bodily relation to the material artifact cannot be developed.

- ⊟ **12. THE MATTER WITH MATTER: SPECIFICITY AND SIMULATION (pg. 14)**
  - ☑ *The difference between theory and practice is greater in practice than in theory* (anon)
  - ☐ *From now on, lessons in rice planting will occur in the paddy fields*. (Notice posted on blackboard in Chinese Cultural Revolution Film *Breaking with Old Ideas*).
  - ☐ In computer science, consistent with the dogma of the general purpose machine, and *platform independent* technologies which succeed from it, hardware is usually taken as a given, and assumed to be adequate or even optimal to the task. The machinations of code can proceed without reference to the real physical world. But in fact, such hardware substrates always come with their specific affordances and constraints, and their interface to the physical world is delimited. In a world of networked databases, required data is (paradigmatically) always unproblematically available in a form which does not require interpretation. Contrarily, the real, biophysical world is a dirty, complex and unpredictable place. Among the robotics community in the 90's, the remark 'fix it in software' was often heard and it was almost always tongue-in-cheek. The remark signalled a recognition that many problems could not be 'fixed in software'. Data is generated by the digisation of signals from sensors which exploit electrophysical phenomena. Specific physically tangible electronic and mechanical technologies have to be designed and tested with respect to specific environments in order to create a context in which code can usefully work. If any part of that 'front-end' process is faulty (wrong alignment or calibration, bad optics, unreliable power supply, unexpected response to environmental factors such as humidity, etc) or if the scaling and parametrisation of the a/d process is inappropriate; then the data representation of the real-world phenomenon is forever flawed. In the spirit of GIGO (Garbage In, Garbage Out), no amount

of software downstream can create more accurate and higher resolution representations of the world than that supplied by the interface with that world. At best it can retrofit a simulation of it, based on accurate measurement of the kinds of errors inherent in the faulty sensor. This, of course, can add a second cycle of inaccurate representation.

- ☐ This tension between the power afforded by abstraction, and the simultaneous loss of precision, is explicit in the case of simulation. By the same (fix it in software) reasoning, computer simulation of real world contexts must be regarded with some reservation. As Eugene Ferguson, among others, has observed, any simulation tool is itself a design artifact, and depends for its representational accuracy on several factors. First, that the designer correctly identified all the relevant physical effects. Second, that such physical effects are amenable to algorithmic representation. Thirdly that these representations are accurate and of adequate resolution. Forth, that all possible interactions of these relevant factors were appropriately calculated and represented. Certain kinds of physical phenomena, particularly those manufactured to reliably embody and express a mathematically simple physical process are more simple to simulate. The behavior of a tree in a storm, or the turbulence of water on a ships hull demand more complex computation, or may be inherently uncomputatable. Here the isomorphic loop of industrialism and engineering stands out in stark relief. A gear train or resistor-capacitor network is easily simulated because these things are themselves produced to embody behavior easily described in newtonian terms. One is inevitably reminded of the Borgesian conceit of the map in 'Of Exactitude in Science". The recognition of the fundamental necessity of computability of a simulation is a reality which seems often forgotten. Inevitably, there are more factors at play in the real world than in the simulation. Thus many practitioners, particularly those trained in the computer science disciplines, are deeply shocked when the real world does not conform to simulation. As Hamlet noted, *There are more things in heaven and earth, Horatio, Than are dreamt of in your philosophy*. [32]

- ⊟ **13. CONCLUSION (pg. 15)**
  - ☑ *"A critical technical practice will, for the foreseeable future, require a split identity,-- one foot planted in the craft work of design and the other foot planted in the reflexive work of critique."* Philip Agre [33]

  - ☐ If the thesis of this paper is taken to be valid, at least in part, then several paths of action are called for. The first is a thoroughgoing assessment of the effects of the computational paradigms on cultural practices, this is both a theoretical inquiry and a context for historical work and case studies. Practitioners are duty-bound to assess the values inherent in the technological tools they employ, lest they sabotage their enterprise. If and when these ontological booby traps are identified, a new mode of technology development is called for: the imagining, design and development of tools consistent with the values which underly and shore up the practice itself; always allowing for the possibility that any form of technology *could be* antithetical to, or destructive of, the cultural enterprise.

- ☐ The other, alternative and parallel path is the negotiation of new cultural practices native to the new technologies, in a process which intelligently and attentively assesses the potential disharmonies between the artistic goals and the qualities of the technologies.

- ☐ Both these kinds of design processes must address the technologies at a plethora of different levels, from the smallest component level to entire devices, from implicit entailments of programming languages to dynamics of the interface and interaction, and everything between.

- ☐ **14. REFERENCES / ENDNOTES (pg. 16)**
- ☐ **Global Summary: (Rough Draft)**
  - ☐ In the article, Simon wants the history of Computational Technology to be acknowledged in current Media Arts practices. He questions the motivations of adopting the methodologies of the tools as absolutes in art making. He argues that the arts primary motivations are to question and to use the hyper specific in human logic to question the Art process itself. What he outlines persuasively is that in this Mathematical logic driven system of Boolean logic the symbolic system and motivations are purely other. The opposite but how is it opposite, and how can an artist control this new paradigm. Is the problem that Artists are adopting this medium not informed, or is the properties of the tools so limited to the state of creativity for artistic objectives. Art for Penny reveals and Technology demonstrates the invisible. Invisible technology for an engineer is seamless and as objectives is in line with current professional practices.(Research to commerce). Knowledge for both Engineering and Arts do not need to be mutually exclusive, but the fundamental motivations of making need to be acknowledged and focused as objectives to either use technology casually or to fundamentally changed and revolutionize the area of disciplines.
  - ☐
  - ☐
- ☐ **Final Drafts**
  - ☐
  - ☐
  - ☐

The NewMedia Reader - Ch. 4 Men, Machines, and the World About (Norbert Weiner) pp 65-72 (Original Publication 1954)

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- ⊟ **_Outline**
  - ⊟ **04. [Introduction] Men, Machines and the World About**
    - ☑ Norbert Wiener began working toward *cybernetics* while engaged in a World War II research project.
    - ☐ This project, like the atomic bomb, was funded and organized by Vannevar Bush's (◊02) academic/industrial/military "iron triangle."
    - ☐ In response to the dropping of the bomb and other horrors of the war, Wiener decided that a new type of scientist was required, a scientist engaged with the consequences of scientific work
    - ☐ Cybernetics is perhaps most immediately recognized for bringing the "cyber" prefix into English usage
    - ☐ Other, less immediately obvious terms were also introduced into common speech by Wiener's writings on cybernetics—including "feedback," "input," and "output." These words had existed in English, but for very narrow technical purposes—for the description of engineering problems, the description of machines. Now they are used to describe human interchanges, as when one asks for "feedback" from a colleague on an idea.
    - ☐ Cyberneticists sought to create an overarching study of "communication and control in the animal and machine."
    - ☐ The work of the cyberneticists was extremely influential, redefining the object of study for many scientists and technologists.
    - ☐ Before cybernetics, technology was largely defined in terms of mechanics. Studies involved movements of power and accompanying observable, physical changes such as one might have found inside Vannevar Bush's memex: its operations of request, recording, calculation, and display moving like an intricate jukebox or clockwork.
    - ☐ When "communication and control" became the object of study, the ground shifted. Communication and control involve power differentials and have physical manifestations, to be sure, but are more akin to the workings of a digital computer: most observable, not with a voltage meter or the gaze of the naked eye, but from the inside, from within the system. And these systems tend to overflow the boundaries of any single object. As a result some previous studies of isolated objects seemed outmoded in a cybernetic context, while cybernetics created

a framework for studying communication and control systems that spread across multiple entities.

- ☐ The first of these studied, and perhaps the defining case of cybernetics, was the subject of the WWII research project on which Wiener worked: the system of a bomber, an anti-aircraft gun, and the human operators of each.
- ☐ As Katherine Hayles points out, this type of study has the effect of eroding liberal humanist ideas of subjectivity.
- ☐ That is to say, if we humans are simply parts of systems—our skins not boundaries but permeable membranes, our actions measured as behavior rather than by introspection—the autonomous, sufficient "self" begins to seem an illusion.
- ☐ Wiener's devotion to social justice—to becoming a scientist engaged with the social outcomes of his work—is particularly notable in the McCarthyite context of the 1950s.
- ☐ "Communication and control" is in some ways synonymous with "interactivity."
- ☐ the foundational and ongoing importance of cybernetics cannot be overstated. This is true not only in the engineering areas of new media, but also in the arts.
- ☐ *An important early exhibition of new media art was Jasia Reichardt's Cybernetic Serendipity. And Jack Burnham and Les Levine's concept of "Software" art (◊16) was, in many ways, constructed as a reaction to the influence of cybernetic concepts on new media art. In the same period, particularly via the influence of John Cage, the arts were also bringing concepts of Zen Buddhism to public consciousness. Nam June Paik (◊15), often considered the first video artist and the first to use television as an art object, considered his work cybernetic and was a close associate of Cage's.*

  —NWF

- ☐ **Quotes:**
  - ☐ *As Heinz von Foerster writes in volume four of Wiener's* Collected Works (*800*):

    A quick comparison of curricula offered in departments of electrical engineering in the early fifties with today's will convince even the skeptic of the significance of [these] ideas: although then almost all that was taught was "power," today almost all that is taught is "communication."
  - ☐ For more on the cyborg, see the next selection by J.C.R. Licklider (◊05) and Donna Harraway's manifesto (◊35). For more on cyberspace, see the article by Chip Morningstar and F. Randall Farmer on (◊46).
  - ☐ *From "A Scientist Rebels," an open letter by Wiener to a research scientist, published in The Atlantic Monthly in January 1947:*

    [When] you turn to me for information concerning controlled missiles, there are several considerations which determine my reply. In the past, the comity of scholars has made it a custom to furnish scientific information to any person seriously seeking it. However, we must face these facts: The policy of the government itself during and after the war, say in the bombing of Hiroshima and Nagasaki, has made it clear that to provide scientific information is not a necessarily innocent act, and may entail the gravest consequences. One therefore cannot escape reconsidering the established custom of the scientist to give information to every person who may inquire of him. The interchange of ideas which is one of the great traditions of science must of course receive certain limitations when the scientist becomes an arbiter of life and death.
  - ☐ *In How We Became Posthuman, Hayles states, "Writing in the years immediately preceding and following World War II, Wiener anticipated some aspects of poststructuralist theories. He questioned whether humans,animals, and machines have any 'essential' qualities that exist in themselves, apart from the web of relations that constituted them in discursive and communicative fields" (91).See the selections from Gilles Deleuze and Felix Guattari (◊27) and Donna Harraway (◊35) for poststructuralist treatments of selfhood.*
  - ☐ *While Zen finds selflessness to be a root of compassion, which in cases such as Vietnamese Nobel Laureate Thich Naht Hanh's leads to direct action, selflessness has often seemed nihilistic to U.S. thinkers —removing the basis for traditional constructions of social justice and life's meaning. It is a question, perhaps, of a small conception of self as opposed to a large one—not that our hand is not part of us, but that much more is.*
- ⊟ **Additional Reading**
  - ☑ *Further Reading*

    Wiener, Norbert. Cybernetics: or Control and Communication in the Animal and the Machine. 2nd Ed. Cambridge: MIT Press, 1965. (1st ed. 1948.)

    Wiener, Norbert. The Human Use of Human Beings : Cybernetics and Society, Da Capo Press, 1988. (Originally published 1950.)

    Wiener, Norbert. Norbert Wiener: Collected Works—Vol. 4: Cybernetics, Science, and Society; Ethics, Aesthetics, and Literary Criticism; Book Reviews and Obituaries, ed. P. Masani, Cambridge: MIT Press, *1986.*

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Reichardt, Jasia, ed. Cybernetic Serendipity: The Computer and the Arts. Exhibition catalog, distributed in the U.S. as a special issue of Studio International, 1969. Exhibition organized by by Jasia Reichardt (with Mark Dowson and Peter Schmidt) at the Institute of Contemporary Arts, Nash House, The Mall, London, August 2-October 20, 1968.

- ☐
- ⊟ **Original Text: Men, Machines and the World About**
  - ☐ **Page 67**
    - ☐ I want to point historically to the various things that got me interested in the problems of man, machines, and the world about, because they are relevant to the various things I shall have to say about the present status of the problem.
    - ☐ There were two converging streams of ideas that brought me into cybernetics.
    - ☐ One of them was the fact that in the last war, or when it was manifestly coming, at any rate before Pearl Harbor, when we were not yet in the conflict, I tried to see if I could find some niche in the war effort.
    - ☐ In that particular problem, I looked for something to do, and found it in connection with automatic computing machines. Automatic computing machines, of what is called an analogy sort, in which physical quantities are mesured and not numbers counted, had already been made very successfully by Professor Vannevar Bush, but there were certain gaps in the theory.
    - ☐ One of the gaps I can express mathematically by saying that these machines could do ordinary differential equations but not partial differential equations. I shall express it physically by the fact that these machines could work in one dimension, namely, time, but not in any efficient way in two dimensions, or three.
    - ☐ Now, it occurred to me that (a) the use of television had shown us a way to represent two or more dimensions on one device; and (b) that the previous device which measured quantities should be replaced by a more precise sort of device that counted numbers.
    - ☐ The report that I gave was, in many ways, not in all, a substantial account of the present situation with automatic computing machines. Thus, I had already become familiar with the idea of the machine which does its arithmetic by making choices on the basis of previous choices, and these on the basis of previous choices, and so on, according to a schedule furnished to the machine by punched tape, or by magnetized tape, or other methods of the sort.
    - ☐ The antiaircraft gun is a very interesting type of instrument. In the First World War, the antiaircraft gun had been developed as a firing instrument, but one still used range tables directly by hand for firing the gun. That meant, essentially, that one had to do all the computation while the plane was flying overhead, and, naturally, by the time you got in position to do something about it, the plane had already done something about it, and was not there.
    - ☐ …that the essence of the problem was to do all the computation in advance and embody it in instruments which could pick up the observations of the plane and fuse them in the proper way to get the necessary result to aim the gun and to aim it, not at the plane, but sufficiently ahead of the plane, so that the shell and the plane would arrive at the same time as induction. That led to some very interesting mathematical theories.
  - ⊟ **Page 68**
    - ☑ Very soon we ran into the following problem: the antiaircraft gun is not an isolated instrument. While it can be fired by radar, the equivalent and obvious method of firing it is to have a gun pointer. The gun pointer is a human element; this human element is joined with the mechanical elements. The actual fire control is a system involving human beings and machines at the same time. It must be reduced, from an engineering point of view, to a single structure, which means either a human interpretation of the machine, or a mechanical interpretation of the operator, or both. We were forced—both for the man firing the gun and for the aviator himself—to replace them in our studies by appropriate machines. The

question arose: How would we make a machine to simulate a gun pointer, and what troubles would one expect with the situation?

- ☐ ...in 1868, by the great physicist, Clerk Maxwell, in a paper in the Proceedings of the Royal Society in London. If the feedback of the rudder, or the governor, is too intense, the apparatus will shoot past the neutral position a little further than it was originally past it on one side—will shoot further past it on the other—and will go into oscillation.
- ☐ Since we thought that the simplest way that we could explain human control was by a feedback, we wondered whether this disease would occur. We went with the following question to our friend, Dr. Arturo Rosenblueth, a physiologist, who was then Cannon's right-hand man in the Harvard Medical School: Is there any nervous disease known in which a person trying to accomplish a task starts swingingwider and wider, and is unable to finish it? For example, I reach for my cigar. I suppose the ordinary way I control my action is so as to reduce the amount by which the cigar has not yet been picked up. Is that disease of excessive oscillation known?
- ☐ The answer was most definitely that this disease is known. It has exactly the symptoms named. It occurs in the pathology of the cerebellum, the little brain. It is known as purpose tremor or cerebellar tremor.
- ☐ Well, that gave us the lead. It looked as if a common pattern could be given to account for human behavior and controlled machine behavior in this case, and that it depended on negative feedback.
- ☐ That was one of the leads we had. The other lead went back to the study of the automatic controlling machine, the automatic computing machine.
- ☐ In the first place, automatic computing machinery is of no value except for one thing: its speed. It is more expensive than the ordinary desk machine, enormously more. You do not get anything out of it unless you use it at high speed. But to use a machine at high speed, it is necessary to see that every operation it carries out is carried out at a corresponding speed. If you mix in slow stages with fast stages of the machine, the slow stages always win out. They more nearly govern the behavior of the machine than the fast stages. Therefore, the commands given to a high-speed computing machine cannot be given by hand, while the machine is running. They must be built in in advance to what is called a taping, like punched cards, like punched tape, like magnetic tape, or something of the sort; and your machine must not only control the numbers and their combinations, but the scheduling of operations. Your machine must be a logical machine.
- ☐ There again we found a great similarity to what a human being was doing. The human nervous system, it is perfectly true, does not exhaust all of human control activity. There is, without any doubt, a control activity in man that goes through hormones, that goes through the blood, and so on. But, as far as the nervous system works, the individual fibers come very near to showing an "all or none" action, that is, they fire or they do not fire; they do not fire halfway. If your individual fibers leading to a given fiber, and connected to it by what is known as a synapse, fire in the proper combination—perhaps at least as many as a certain number—and if certain so-called inhibitory fibers do not interrupt them, the outgoing fibers fire. Otherwise they do not.

- ☐ **Page 69**
  - ☐ This is an operation of connected switching extremely like the connected switching of the automatic computing machine. This led us to another comparison between the nervous system and the computing machine, and led us, furthermore, to the idea that since the nervous system is not only a computing machine but a control machine, that we may make very general control machines, working on the successive switching basis and much more like the control machine part, the scheduling part of a computing machine, than we might otherwise have thought possible.
  - ☐ In particular, it seemed to us a very hopeful thing to make an automatic feedback control apparatus in which the feedback itself was carried out, in large measure, by successive switching operations such as one finds either in the nervous system or in the computing machine.

- ☐ It was the fusion of these two ideas, each of which has a human or animal side and has a machine side, which led to *Cybernetics*…..I chose the name, for I felt that this particular combination of ideas could not be left too long unbaptized, took it from the Greek word κυβερναν meaning to govern, as essentially the art of the steersman.
- ☐ From here on, I can go ahead in very many ways. The first thing that I want to say is that the feedback mechanisms are not only well known to occur in the voluntary actions of the human body, but that they are necessary for its very life.
- ☐ A few years ago, Professor Henderson of Harvard wrote a book entitled *The Fitness of the Environment*. Anybody who has read that book must regard it as very much of a miracle that any organism can live, and particularly a human organism. Man cannot exist over any variety of temperatures. For that matter, there is no active life, certainly not above the boiling point and below the freezing point, and most planets probably do not have temperatures lying in that convenient range. When I say "boiling point" and "freezing point," I mean of water, because water is a very distinct and special sort of chemical substance.
- ☐ Now, even a fish cannot exist at the boiling point. It can exist at something like our own temperature to something around the freezing point, perhaps a little bit below, but not much below.
- ☐ We cannot do anything like that. We either have a chill or a fever if we get near it. The temperature at which life is possible does not vary for man for any extended period of time. It certainly does not vary much over ten degrees, and practically varies much less than that. Again, we must live under constant conditions of saltiness of our blood, of urea concentration in our blood, and so on.
- ☐ How do we do this? The idea goes back to Claude Bernard and was developed very much by Cannon. We are full of what is called homeostatic mechanisms, which are mechanisms like thermostats. A homeostat is a mechanism which keeps certain bodily conditions within a narrow range. One of those homeostats, located partly, at least, in the medulla, regulates temperature. Another one regulates breathing. Another one of them regulates urea concentration. That is the apparatus of the kidneys. There are not only a few, but many, many such controls.
- ☐ Now, such control is like the house thermostat. The house thermostat, if you remember it, is a piece of apparatus which has a little thermometer in it made of two pieces of metal. It makes a contact at one temperature and breaks it at others, and it regulates the admission of oil to the furnace and the ignition of that oil. The interesting thing is it has its own pathology. Many of you people must know that.

  We have a house in which there is a thermostat which some brilliant architect placed in the only room in the house with a fireplace. The result is that if we want to cool the house in winter, we light the fire because we give false information to the thermostat that the house is warm and the thermostat turns out the furnace fire.

- ☐ **Page 70**
  - ☐ There is another side to this which is also interesting. The homeostats in the body that I have spoken of are built into the human body. Can we make a homeostat that is partly in the body and partly outside? The answer is definitely yes.
  - ☐ Dr. Bickford at the Mayo Clinic—and he has been followed in this by Dr. Verzeano in the Cushing Veterans Hospital in Framingham—has made an apparatus which takes the brain waves of the electroencephalogram and divides them up, using the total amount that has passed for a stated time, to inject anesthetic either into the vein or into a mask….I think that the administration of drugs by homeostats which are monitored by their physiologic consequences is a field which has a great future.
  - ☐ Chemistry is an interesting case in point. A chemical factory is generally full of pipes carrying acids, or alkalis, or explosives—at any rate, substances dangerous to work with. When certain thermometers reach certain readings, and certain pressures have been reached, and so on, somebody turns certain valves. He had better turn the right valves, particularly in

something like an oil-cracking plant or atomic energy plant, where we are dealing with radioactive materials.

If he has to turn valves on the basis of readings, then, as in the antiaircraft gun, we can build in advance the combinations which should turn valves as distinguished from those which should not. The valves may be turned through amplifiers, through what is essentially computing apparatus, by the reading of the instruments themselves, the instruments or sense organs.

You may say, "Very good, but you have to have a man to provide for emergencies."

By the way, it is extremely desirable not to have people in a factory that is likely to explode. People are expensive to replace, and besides we have certain elementary humanitarian instincts.

- ☐ The question is: Is a man likely to use better emergency judgment than a machine? The answer is no. The reason for that is this: Any emergency you can think of, you can provide for in your computing and control apparatus. If before the time of the emergency, you cannot think of what to do, during the emergency you are almost certain to make a wrong decision. If you cannot figure out a reasonable course of conduct in advance, you simply do not find that the Lord will give you the right thing to do when the emergency comes. Emergencies are provided for in times of peace. I also mean by that, emergencies like the falling of an atomic bomb, about which I may or may not have something to say later.
- ☐ Then, for perfectly legitimate or even humanitarian reasons, the automatic control system is coming in in the chemical industry and in other especially dangerous industries. However, the same techniques that make possible the automatic assembly line for automobiles, perhaps one automatic assembly line in the textiles industry, and possibly even in dozens of other industries.

  The interesting thing is this: that while the successive orders that you give can be almost indefinitely varied in a machine, the instruments which elaborate successive orders are practically standard, no matter what you are doing. These are two variables: one is the quasihuman hands to which the central machine leads, and the other is the sequence of orders put in.
- ☐ To change from one set of orders, say, from one make of car to another, or to change from one style of body to another, in an assembly line, it is not necessary to alter the order-giving machine. It is enough to alter the particular taping of that machine.

- ⊟ **Page 71**
  - ☑ I suppose a good many of you have seen the movie, "Cheaper by the Dozen." …..However, when you have simplified a task by reducing it to a routine of consecutive procedures, you have done the same sort of thing that you need to do to put the task on a tape and run the procedure by a completely automatic machine. The problem of industrial management and the systematic handling of ordinary detail by the Gilbraiths, and so forth, is almost the same problem as the taping of a control machine; so that instead of actually improving the conditions of the worker, their advance has tended to telescope the worker out of the picture. That is a very important thing, because it is a procedure taking place now.
  - ☐ I want to say that we are facing a new industrial revolution. The first industrial revolution represented the replacement of the energy of man and of animals by the energy of the machine. The steam engine was its symbol. That has gone so far that there is nothing that steam and the bulldozer cannot do. There is no rate at which pure pick- and-shovel work can be paid in this country which will guarantee a man's doing it willingly. It is simply economically impossible to compete with a bulldozer for bulldozer work.

    The new industrial revolution which is taking place now consists primarily in replacing human judgment and discrimination at low levels by the discrimination of the machine. The machine appears now, not as a source of power, but as a source of control and a source of communication. We communicate with the machine and the machine communicates with us.

Machines communicate with one another. Energy and power are not the proper concepts to describe this new phenomenon.

- ☐ If we, in a small way, make human tasks easier by replacing them with a machine execution of the task, and in a large way eliminate the human element in these tasks, we may find we have essentially burned incense before the machine god. There is a very real danger in this country in bowing down before the brass calf, the idol, which is the gadget. I know a great engineer who never thinks further than the construction of the gadget and never thinks of the question of the integration between the gadget and human beings in society. If we allow things to have a reasonably slow development, then the introduction of the gadget as it naturally comes may hurt us enough to provoke a salutary response. So, we realize we cannot worship the gadget and sacrifice the human being to it, but a situation is easily possible in which we may incur a disaster.

- ⊟ **Page 72**
  - ☑ Well, you see the picture drawing together. I suppose one of the things that you people would like would be consolation. Gentlemen, there is no Santa Claus! If we want to live with the machine, we must understand the machine, we must not worship the machine. We must make a great many changes in the way we live with other people. We must value leisure. We must turn the great leaders of business, of industry, of politics, into a state of mind in which they will consider the leisure of people as their business and not as something to be passed off as none of their business.
  - ☐ We shall have to realize that while we may make the machines our gods and sacrifice men to machines, we do not have to do so. If we do so, we deserve the punishment of idolators. It is going to be a difficult time. It we can live through it and keep our heads, and if we are not annihilated by war itself and our other problems, there is a great chance of turning the machine to human advantage, but the machine itself has no particular favor for humanity.
  - ☐ It is possible to make two kinds of machines (I shall not go into the details): the machine whose taping is determined once and for all, and the machine whose taping is continually being modified by experience. The second machine can, in some sense, learn.
  - ☐ Gentlemen, the moral problem of the machine differs in no way from the old moral problem of magic. The fact that the machine follows the law of Nature and that magic is supposed to be outside of Nature is not an interesting distinction. Sorcery was condemned in the Middle Ages. In those ages certain modern types of gadgeteer would have been hanged or burned as a sorcerer. An interesting thing is that the Middle Ages to a certain extent—oh, I don't mean in its love for the flame, but in its condemnation of the gadgeteer—would have been right; namely, sorcery was not the use of the supernatural, but the use of human power for other purposes than the greater glory of God.
  - ☐ You know Jacob's story of the monkey's paw, the talisman. An old couple came into possession of this, and learned that it would grant them three wishes. The first wish was for two hundred pounds. Immediately, a man appeared from the factory to say that their boy had been crushed in the machinery, and although the factory recognized no responsibility, they were ready to give a solatium of two hundred pounds.

    After this they wished the boy back again, and his ghost appeared.

    Then they wished the ghost to go away, and there they were left with nothing but a dead son. That is the story.

    This is a piece of folklore; but the problem is quite as relevant to the machine as to any piece of magic.
  - ☐ However, a machine can learn. Here the folklore parallel is to the tale of the fisherman and the genie. You all know the story. The fisherman opens a bottle which he has found on the shore, and the genie appears. The genie threatens him with vengeance for his own imprisonment. The fisherman talks the genie back into the bottle. Gentlemen, when we get into trouble with the machine, we cannot talk the machine back into the bottle.

- ☐ **Global Summary: (Rough Draft)**

The NewMedia Reader - Ch. 4 Men, Machines, and the World About (Norbert Weiner) pp 65-72 (Original Publication 1954) **Links:**

- ☐ Norbert Wieners analysis of systems led him to the realizations that the unification of man in machine is implied by human biology. The facts that our bodies are made up of many types of machines. Biological Machines that can be identified as metaphors such as the house thermostat as a regulatory device for the home.
- ☐
- ☐

- ☐ **Final Drafts**

On Self-Organizing Systems and Their Environments (Heinz.Von Foerster) pp. 1-19 (19) **Links**

- ☑ **_Article Summary:**
  - ☑ *Understanding understanding*, Essays on Cybernetics and Cognition, a volume of H. von Foerster's papers
  - ☑ Author: Heinz.Von Foerster
  - ☑ On Self-Organizing Systems and Their Environments (Heinz.Von Foerster) pp. 1-19 (19)
  - ☑ Year: 2002
  - ☑ Publisher: Springer-Verlag,
- ☐ **_Bibliography**
- ⊟ **_Glossary**
  - ☐ **Major Concepts:**
  - ☐ **Terms**
  - ⊟ **References:**
    - ☐ **Influential Artists/Thinkers:**
      - ☐ Heinz von Förster — en.wikipedia.org–
      - ☐ Gordon Pask — en.wikipedia.org–
      - ☐ Ludwig Boltzmann — en.wikipedia.org–
      - ☐ Claude Shannon — en.wikipedia.org–
      - ☐ Erwin Schrodinger — en.wikipedia.org–
    - ⊟ **Concepts**
      - ☐ Cybernetics: — en.wikipedia.org-
      - ☐ Self Organization: — en.wikipedia.org-
      - ☐ SELF-ORGANIZING SYSTEM — pespmc1.vub.ac.t
      - ☐ Entropy — en.wikipedia.org-
      - ☐ Thermodynamics — en.wikipedia.org-
      - ☐ Laws of thermodynamics — en.wikipedia.org-
      - ☐ Heat Death — en.wikipedia.org-
      - ☐ Reductio ad absurdum — en.wikipedia.org-
      - ☐ *conditio sine qua non* — *en.wikipedia.org-*
      - ☐ *Tautology:* — *en.wikipedia.org-*
      - ☐ *Logic:* — *en.wikipedia.org-*
      - ☑ Inductive Reasoning (Bottom-up logic) — en.wikipedia.org–
      - ☐ Abductive Reasoning (guessing - logic through observation) — en.wikipedia.org–
      - ☐ Deductive Reasoning (Top-down logic) — en.wikipedia.org–
      - ☐ What is Life — en.wikipedia.org–
      - ☐ Information Theory: — en.wikipedia.org–
    - ☐ **Online Sources:**
- ⊟ **_Outline**
  - ⊟ **Page 01**
    - ☑ "What makes a self-organizing system?" Thus, I hope you will forgive me if I open my paper by presenting the following thesis: "There are no such things as self-organizing systems!"
    - ☐ I shall now prove the non-existence of self-organizing systems by *reductio ad absurdum* of the assumption that there is such a thing as a self-organizing system.
    - ☐ Assume a finite universe, U_0, as small or as large as you wish (see Fig. 1*a*), which is enclosed in an adiabatic shell which separates this finite uni- verse from any "meta-universe" in which it may be immersed. Assume, fur- thermore, that in this universe, U_0, there is a closed surface which divides this universe into two mutually exclusive parts: the one part is completely occupied with a self-organizing system S_0, while the other part we may call the environment E_0 of this self-organizing system: S_0 & $E_0 = U_0$.

      I may add that it is irrelevant whether we have our self-organizing system inside or outside the closed surface. However, in Fig. 1 the system is assumed to occupy the interior of the dividing surface.

      Undoubtedly, if this self-organizing system is permitted to do its job of organizing itself for a little while, its entropy must have decreased during this time:…otherwise we would not call it a self-organizing system, but just a mechan- ical $dS_s/dt = 0$, or a thermodynamical $dS_s/dt > 0$ system. In order to accom- plish this, the entropy in the remaining part of our finite universe, i.e. the entropy in the environment must have increased
  - ☐ **Page 02**
    - ☐ otherwise we would not call it a self-organizing system, but just a mechan- ical $dS_s/dt = 0$, or a thermodynamical $dS_s/dt > 0$ system. In order to accom- plish this, the entropy in the remaining part of our finite universe, i.e. the entropy in the environment must have increased

      …otherwise the Second Law of Thermodynamics is violated. If now some of the processes which contributed to the decrease of entropy of the system are irreversible we will find the entropy of the universe U_0 at a higher level than before our system started to organize itself, hence the state of the universe will be more disorganized than before $dS_U/dt > 0$, in other words, the activity of the system was a disorganizing one, and we may justly call such a system a "disorganizing system."
    - ☐ However, it may be argued that it is unfair to the system to make it responsible for changes in the whole universe and that this apparent inconsistency came about by not only paying attention to the system proper but also including into the consideration the environment of the system. By drawing too large an adiabatic envelope one may include processes not at all relevant to this argument. All right then, let us have the adiabatic envelope coincide with the closed surface which previously separated the system from its environment (Fig. 1*b*). This step will not only invalidate the above argument, but will also enable me to show that if one assumes that this envelope contains the self-organizing system proper, this system turns out to be not only just a disorganizing system but even a self-disorganizing system.
  - ☐ **Page 03**
    - ☐ It is clear from my previous example with the large envelope, that here too—if irreversible processes should occur—the entropy of the system now within the envelope must increase, hence, as time goes on, the system would disorganize itself, although in certain regions the entropy may indeed have decreased. One may now insist that we should have wrapped our envelope just around this region, since it appears to be the proper self-

organizing part of our system. But again, I could employ that same argument as before, only to a smaller region, and so we could go on for ever, until our would-be self- organizing system has vanished into the eternal happy hunting grounds of the infinitesimal.

- ☐ In spite of this suggested proof of the non-existence of self-organizing systems, I propose to continue the use of the term “self-organizing system,” whilst being aware of the fact that this term becomes meaningless, unless the system is in close contact with an environment, *which posseses available energy and order*, and with which our system is in a state of perpetual inter- action, such that it somehow manages to “live” on the expenses of this environment.
- ☐ Although I shall not go into the details of the interesting discussion of the energy flow from the environment into the system and out again, I may briefly mention the two different schools of thought associated with this problem, namely, the one which considers energy flow and signal flow as a strongly linked, single-channel affair (i.e. the message carries also the food, or, if you wish, signal and food are synonymous) while the other viewpoint carefully separates these two, although there exists in this theory a significant interdependence between signal flow and energy availability.
- ☐ I confess that I do belong to the latter school of thought and I am par- ticularly happy that later in this meeting Mr. Pask, in his paper *The Natural History of Networks*,[2] will make this point of view much clearer than I will ever be able to do.
- ☐ What interests me particularly at this moment is not so much the energy from the environment which is digested by the system, but its utilization of environmental order. In other words, the question I would like to answer is: “How much order can our system assimilate from its environment, if any at all?”
- ☐ Before tackling this question, I have to take two more hurdles, both of which represent problems concerned with the environment. Since you have undoubtedly observed that in my philosophy about self-organizing systems the environment of such systems is a *conditio sine qua non* I am first of all obliged to show in which sense we may talk about the existence of such an environment. Second, I have to show that, if there exists such an environment, it must possess structure.

- ☐ **Page 04**
  - ☐ The first problem I am going to eliminate is perhaps one of the oldest philosophical problems with which mankind has had to live. This problem arises when we, men, consider ourselves to be self-organizing systems. We may insist that introspection does not permit us to decide whether the world as we see it is “real,” or just a phantasmagory, a dream, an illusion of our fancy. A decision in this dilemma is in so far pertinent to my discussion, since —if the latter alternative should hold true—my original thesis assert- ing the nonsensicality of the conception of an isolated self-organizing system would pitiably collapse.
  - ☐ I shall now proceed to show the reality of the world as we see it, by *reduc- tio ad absurdum* of the thesis: this world is only in our imagination and the only reality is the imagining “I”.

    Thanks to the artistic assistance of Mr. Pask who so beautifully illustrated this and some of my later assertions,* it will be easy for me to develop my argument.
  - ☐ Assume for the moment that I am the successful business man with the bowler hat in Fig. 2, and I insist that I am the sole reality, while everything else appears only in my imagination. I cannot deny that in my imagination there will appear people, scientists, other successful businessmen, etc., as for instance in this conference. Since I find these apparitions in many respects similar to myself, I have to grant them the privilege that they themselves may insist that they are the sole reality and everything else is only a con- coction of their imagination. On the other hand, they cannot deny that their fantasies will be populated by people—and one of them may be I, with bowler hat and everything!

    With this we have closed the circle of our contradiction: If I assume that I am the sole reality, it turns out that I am the imagination of somebody else, who in turn assumes that *he* is the sole reality. Of course, this paradox is easily resolved, by postulating the reality of the world in which we happily thrive.
  - ☐ Having re-established reality, it may be interesting to note that reality appears as a consistent reference frame for at least two observers. This becomes particularly transparent, if it is realized that my “proof” was exactly modeled after the “Principle of Relativity,” which roughly states that, if a hypothesis which is applicable to a set of objects holds for one object and it holds for another object, then it holds for both objects simul- taneously, the hypothesis is acceptable for all objects of the set. Written in terms of symbolic logic, we have:

    $(Ex)\,[H(a) \;\&\; H(x) \dashrightarrow H(a+x)] \dashrightarrow (x)H(x)$

    Copernicus could have used this argument to his advantage, by pointing out that if we insist on a geocentric system, $[H(a)]$, the Venusians, e.g. could insist on a venucentric system $[(Hx)]$. But since we cannot be both, center and epicycloid at the same time $[H(a+x)]$, something must be wrong with a planetocentric system.

- ⊟ **Page 05**
  - ☑ However, one should not overlook that the above expression, R(H) is not a tautology, hence it must be a meaningful statement.* What it does, is to establish a way in which we may talk about the existence of an environment.
  - ☐ Note:
  - ☐ * This was observed by Wittgenstein,[6] although he applied this consideration to the principle of mathematical induction. However, the close relation between the induction and the relativity principle seems to be quite evident. I would even venture to say that the principle of mathematical induction is the relativity principle in number theory.

- ☐ **Page 06**
  - ☐ Before I can return to my original question of how much order a self- organizing system may assimilate from its environment, I have to show that there is some structure in our environment. This can be done very easily indeed, by pointing out that we are obviously not yet in the dreadful state of Boltzmann’s “Heat-Death.” Hence, presently still the entropy increases, which means that there must be some order—at least now—otherwise we could not lose it.
  - ☐ Let me briefly summarize the points I have made until now:

    . (1) By a self-organizing system I mean that part of a system that eats energy and order from its environment.

    . (2) There is a reality of the environment in a sense suggested by the acceptance of the principle of relativity.

    . (3) The environment has structure.

  - ☐ Let us now turn to our self-organzing systems. What we expect is that the systems are increasing their internal order. In order to describe this process, first, it would be nice if we would be able to define what we mean by “inter- nal,” and second, if we would have some measure of order.
  - ☐ The first problem arises whenever we have to deal with systems which do not come wrapped in a skin. In such cases, it is up to us to define the closed boundary of our system. But this may cause some trouble, because, if we specify a certain region in space as being intuitively the proper place to look for our self-organizing system, it may turn out that this region does not show self-organizing properties at all, and we are forced to make another choice, hoping for more luck this time. It is this kind of difficulty which is encountered, e.g., in connection with the problem of the “localization of functions” in the cerebral cortex.

    Of course, we may turn the argument the other way around by saying that we define our boundary at any instant of time as being the envelope of that region in space which shows the desired increase in order. But here we run into some trouble again; because I do not know of any gad get which would indicate whether it is plugged into a self-*dis*organizing or self-organizing region, thus providing us with a sound operational definition.

Another difficulty may arise from the possibility that these self- organizing regions may not only constantly move in space and change in shape, they may appear and disappear spontaneously here and there, requiring the "ordometer" not only to follow these all-elusive systems, but also to sense the location of their formation.

With this little digression I only wanted to point out that we have to be very cautious in applying the word "inside" in this context, because, even if the position of the observer has been stated, he may have a tough time saying what he sees.

- ☐
- ⊟ **Page 07**
  - ☑ Let us now turn to the other point I mentioned before, namely, trying to find an adequate measure of order. It is my personal feeling that we wish
  - ☐ to describe by this term two states of affairs. First, we may wish to account for apparent relationships between elements of a set which would impose some constraints as to the possible arrangements of the elements of this system. As the organization of the system grows, more and more of these relations should become apparent. Second, it seems to me that order has a relative connotation, rather than an absolute one, namely, with respect to the maximum disorder the elements of the set may be able to display. This suggests that it would be convenient if the measure of order would assume values between zero and unity, accounting in the first case for maximum disorder and, in the second case, for maximum order. This eliminates the choice of "neg-entropy" for a measure of order, because neg-entropy always assumes finite values for systems being in complete disorder. However, what Shannon[3] has defined as "redundancy" seems to be tailor-made for describing order as I like to think of it. Using Shannon's definition for redundancy we have: R = 1- H/Hm whereby H/H_m is the ratio of the entropy H of an information source to the maximum value, H_m, it could have while still restricted to the same symbols. Shannon calls this ratio the "relative entropy." Clearly, this expression fulfills the requirements for a measure of order as I have listed them before. If the system is in its maximum disorder $H = H_m$, R becomes zero; while, if the elements of the system are arranged such that, given one element, the position of all other elements are determined, the entropy— or the degree of uncertainty—vanishes, and R becomes unity, indicating perfect order.

    What we expect from a self-organizing system is, of course, that, given some initial value of order in the system, this order is going to increase as time goes on. With our expression (2) we can at once state the criterion for a system to be self-organizing, namely, that the rate of change of R should be positive:

    see equation 3

    Differentiating eq. (2) with respect to time and using the inequality (3) we have:

    see equation 4

    Since $H_m^2 > 0$, under all conditions (unless we start out with systems which can only be thought of as being always in perfect order: $H_m = 0$),
- ☐ **Page 08**
  - ☐ we find the condition for a system to be self-organzing expressed in terms of entropies:

    see equation 5

    In order to see the significance of this equation let me first briefly discuss two special cases, namely those, where in each case one of the two terms H, H_m is assumed to remain constant.

    (*a*) $H_m = \text{const.}$

    Let us first consider the case, where H_m, the maximum possible entropy of the system remains constant, because it is the case which is usually visu- alized when we talk about self-organzing systems. If H_m is supposed to be constant the time derivative of H_m vanishes, and we have from eq. (5):

    for see equation 6
  - ☐ This equation simply says that, when time goes on, the entropy of the system should decrease. We knew this already—but now we may ask, how can this be accomplished? Since the entropy of the system is dependent upon the probability distribution of the elements to be found in certain dis- tinguishable states, it is clear that this probability distribution must change such that H is reduced. We may visualize this, and how this can be accom- plished, by paying attention to the factors which determine the probability distribution. One of these factors could be that our elements possess certain properties which would make it more or less likely that an element is found to be in a certain state. Assume, for instance, the state under consideration is "to be in a hole of a certain size." The probability of elements with sizes larger than the hole to be found in this state is clearly zero. Hence, if the elements are slowly blown up like little balloons, the probability distribu- tion will constantly change. Another factor influencing the probability dis- tribution could be that our elements possess some other properties which determine the conditional probabilities of an elements to be found in certain states, given the state of other elements in this system.
  - ☐ Again, a change in these conditional probabilities will change the probability distribution, hence the entropy of the system. Since all these changes take place internally I'm going to make an "internal demon" responsible for these changes. He is the one, e.g. being busy blowing up the little balloons and thus changing the probability distribution, or shifting conditional probabilities by establishing ties between elements such that H is going to decrease. Since we have some familiarity with the task of this demon, I shall leave him for a moment and turn now to another one, by discussing the second special case I mentioned before, namely, where H is supposed to remain constant.
- ⊟ **Page 09**
  - ☑ $H = \text{const.}$
  - ☐ If the entropy of the system is supposed to remain constant, its time derivative will vanish and we will have from eq. (5) for

    see equation 7
  - ☐ Thus, we obtain the peculiar result that, according to our previous definition of order, we may have a self-organizing system before us, if its possible maximum disorder is increasing. At first glance, it seems that to achieve this may turn out to be a rather trivial affair, because one can easily imagine simple processes where this condition is fulfilled. Take as a simple example a system composed of N elements which are capable of assuming certain observable states. In most cases a probability distribution for the number of elements in these states can be worked out such that H is maximized and an expression for H_m is obtained. Due to the fact that entropy (or, amount of information) is linked with the logarithm of the probabilities, it is not too difficult to show that expressions for H_m usually follow the general form*:

    $H_m = C_1 + C_2 \log_2 N.$

    This suggests immediately a way of increasing H_m, namely, by just increas- ing the number of elements constituting the system; in other words a system that grows by incorporating new elements will increase its maximum en- tropy and, since this fulfills the criterion for a system to be self-organizing (eq. 7), we must, by all fairness, recognize this system as a member of the distinguished family of self-organizing systems.

- ☐ It may be argued that if just adding elements to a system makes this a self-organizing system, pouring sand into a bucket would make the bucket a self-organizing system. Somehow—to put it mildly—this does not seem to comply with our intuitive esteem for members of our distinguished family. And rightly so, because this argument ignores the premise under which this statement was derived, namely, that during the process of adding new elements to the system the entropy *H* of the system is to be kept con- stant. In the case of the bucket full of sand, this might be a ticklish task, which may conceivably be accomplished, e.g. by placing the newly admit- ted particles precisely in the same order with respect to some distinguish- able states, say position, direction, etc. as those present at the instant of admission of the newcomers. Clearly, this task of increasing H_m by keeping *H* constant asks for superhuman skills and thus we may employ another demon whom I shall call the “external demon,” and whose business it is to admit to the system only those elements, the state of which complies with the conditions of, at least, constant internal entropy. As you certainly have noticed, this demon is a close relative of Maxwell’s demon, only that to-day

- ☐ **Page 10**
  - ☐ these fellows don’t come as good as they used to come, because before 1927[4] they could watch an arbitrary small hole through which the newcomer had to pass and could test with arbitrary high accuracy his momentum. Today, however, demons watching closely a given hole would be unable to make a reliable momentum test, and vice versa. They are, alas, restricted by Heisenberg’s uncertainty principle.
  - ☐ see equation
  - ☐ From this equation we can now easily see that, if the two demons are per- mitted to work together, they will have a disproportionately easier life com- pared to when they were forced to work alone. First, it is not necessary that D_i is always decreasing the instantaneous entropy *H*, or D_e is always increas- ing the maximum possible entropy H_m; it is only necessary that the product of D_i’s results with D_e’s efforts is larger than the product of D_e’s results with D_i’s efforts. Second, if either *H* or H_m is large, D_e or D_i respectively can take it easy, because their efforts will be multiplied by the appropriate factors. This shows, in a relevant way, the interdependence of these demons. Because, if D_i was very busy in building up a large *H*, D_e can afford to be lazy, because his efforts will be multiplied by D_i’s results, and vice versa. On the other hand, if D_e remains lazy too long, D_i will have nothing to build on and his output will diminish, forcing D_e to resume his activity lest the system ceases to be a self-organizing system.

- ⊟ **Page 11**
  - ☑ In addition to this entropic coupling of the two demons, there is also an energetic interaction between the two which is caused by the energy requirements of the internal demon who is supposed to accomplish the shifts in the probability distribution of the elements comprising the system. This requires some energy, as we may remember from our previous example, where somebody has to blow up the little balloons. Since this energy has been taken from the environment, it will affect the activities of the external demon who may be confronted with a problem when he attempts to supply the system with choice-entropy he must gather from an energetically depleted environment.
  - ☐ In concluding the brief exposition of my demonology, a simple diagram may illustrate the double linkage between the internal and the external demon which makes them entropically (*H*) and energetically (*E*) interdependent.
  - ☐ For anyone who wants to approach this subject from the point of view of a physicist, and who is conditioned to think in terms of thermodynamics and statistical mechanics, it is impossible not to refer to the beautiful little monograph by Erwin Schrodinger *What is Life*.[5] Those of you who are familiar with this book may remember that Schrodinger admires particu- larly two remarkable features of living organisms. One is the incredible high order of the genes, the “hereditary code-scripts” as he calls them, and the other one is the marvelous stability of these organized units whose delicate structures remain almost untouched despite their exposure to thermal agi- tation by being immersed—e.g. in the case of mammals—into a thermostat, set to about 310°K.
  - ☐ In the course of his absorbing discussion, Schrodinger draws our atten- tion to two different basic “mechanisms” by which orderly events can be produced: “The statistical mechanism which produces order from disorder and the . . . [other] one producing ‘order from order’.”
  - ☐ While the former mechanism, the “order from disorder” principle is merely referring to “statistical laws” or, as Schrodinger puts it, to “the mag- nificent order of exact physical law coming forth from atomic and molecu- lar disorder,” the latter mechanism, the “order from order” principle is, again in his words: “the real clue to the understanding of life.” Already earlier in his book Schrodinger develops this principle very clearly and states: “What an organism feeds upon is negative entropy.” I think my demons would agree with this, and I do too.
  - ☐ However, by reading recently through Schrodinger’s booklet I wondered how it could happen that his keen eyes escaped what I would consider a “second clue” to the understanding of life, or—if it is fair to say—of self- organizing systems. Although the principle I have in mind may, at first glance, be mistaken for Schrodinger’s “order from disorder” principle, it has in fact nothing in common with it. Hence, in order to stress the difference between the two, I shall call the principle I am going to introduce to you presently the “order from noise” principle. Thus, in my restaurant self-organizing systems do not only feed upon order, they will also find noise on the menu.
  - ☐ Let me briefly explain what I mean by saying that a self-organizing system feeds upon noise by using an almost trivial, but nevertheless amusing example.
- ☐ **Page 12**
  - ☐ Assume I get myself a large sheet of permanent magnetic material which is strongly magnetized perpendicular to the surface, and I cut from this sheet a large number of little squares (Fig. 3*a*). These little squares I glue to all the surfaces of small cubes made of light, unmagnetic material, having the same size as my squares (Fig. 3*b*). Depending upon the choice of which sides of the cubes have the magnetic north pole pointing to the outside (Family I), one can produce precisely ten different families of cubes as indi- cated in Fig. 4.
  - ☐ Suppose now I take a large number of cubes, say, of family I, which is characterized by all sides having north poles pointing to the outside (or family I ¢ with all south poles), put them into a large box which is also filled with tiny glass pebbles in order to make these cubes float under friction and start shaking this box. Certainly, nothing very striking is going to happen: since the cubes are all repelling each other, they will tend to distribute them- selves in the available space such that none of them will come too close to its fellow-cube. If, by putting the cubes into the box, no particular ordering principle was observed, the entropy of the system will remain constant, or, at worst, increase a small amount.

- ⊟ **Page 13**
  - ☑ In order to make this game a little more amusing, suppose now I collect a population of cubes where only half of the elements are again members belonging to family I (or I¢) while the other half are members of family II (or II¢) which is characterized by having only one side of different mag- netism pointing to the outside. If this population is put into my box and I go on shaking, clearly, those cubes with the single different pole pointing to the outside will tend, with overwhelming probability, to mate with members of the other family, until my cubes have almost all paired up. Since the con- ditional probabilities of finding a member of family II, given the locus of a member of family I, has very much increased, the entropy of the system has gone down, hence we have more order after the shaking than before. It is easy to show* that in this case the amount of order in our system went up from zero to

    $R\infty = 1 / \log_2 (en)'$

    if one started out with a population density of *n* cubes per unit volume.

- ☐ I grant you, that this increase in orderliness is not impressive at all, par- ticularly if the population density is high. All right then, let's take a population made up entirely of members belonging to family IVB, which is characterized by opposite polarity of the two pairs of those three sides which join in two opposite corners. I put these cubes into my box and you shake it. After some time we open the box and, instead of seeing a heap of cubes piled up somewhere in the box (Fig. 5), you may not believe your eyes, but an incredibly ordered structure will emerge, which, I fancy, may

  pass the grade to be displayed in an exhibition of surrealistic art (Fig. 6).

- ☐ If I would have left you ignorant with respect to my magnetic-surface trick and you would ask me, what is it that put these cubes into this remark- able order, I would keep a straight face and would answer: The shaking, of course—and some little demons in the box.
- ☐ With this example, I hope, I have sufficiently illustrated the principle I called "order from noise," because no order was fed to the system, just cheap undirected energy; however, thanks to the little demons in the box, in the long run only those components of the noise were selected which contributed to the increase of order in the system. The occurrence of a mutation e.g. would be a pertinent analogy in the case of gametes being the systems of consideration.

- ☐ Hence, I would name two mechanisms as important clues to the under- standing of self-organizing systems, one we may call the "order from order" principle as Schrodinger suggested, and the other one the "order from noise" principle, both of which require the co-operation of our demons who are created along with the elements of our system, being manifest in some of the intrinsic structural properties of these elements.

- ☐ **Page 14**
  - ☐ I may be accused of having presented an almost trivial case in the attempt to develop my order from noise principle. I agree. However, I am convinced that I would maintain a much stronger position, if I would not have given away my neat little trick with the magnetized surfaces.
  - ☐ Dr. Auerbach[6] who later in this meeting will tell us about his beautiful experiments *in vitro* of the reorganization of cells into predetermined organs after the cells have been completely separated and mixed.
  - ☐ I could recover my thesis that without having some knowledge of the mechanisms involved, my example was not too trivial after all, and self-organizing systems still remain miraculous things.
  - ☐
- ☐ **Apendix:**
  - ☐ Please see equations and diagrams
  - ☐
- ☑ **References:**
  - ☑ 1. L. Wittgenstein, *Tractatus Logico-Philosophicus*, paragraph 6.31, Humanities Publishing House, New York (1956).

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    2. G. A. Pask, The natural history of networks. This volume, p. 232.
    3. C. Shannon and W. Weaver, *The Mathematical Theory of Communication*, p. 25,

    University of Illinois Press, Urbana, Illinois (1949).

    4. W. Heisenberg, *Z. Phys*. **43**, 172 (1972).
    5. E. Shrodinger, *What is Life?* pp. 72, 80, 80, 82, Macmillan, New York (1947).
    6. R. Auerbach, Organization and reorganization of embryonic cells. This volume,

    p. 101.

- ☐ **Discussion:**
  - ☐ Lederman (*University of Chicago*): I wonder if it is true that in your definition of order you are really aiming at conditional probabilities rather than just an order in a given system, because for a given number of elements in your system, under your definition of order, the order would be higher in a system in which the information content was actually smaller than for other systems.

    von Foerster: Perfectly right. What I tried to do here in setting a measure of order, was by suggesting redundancy as a measure. It is easy to handle. From this I can derive two statements with respect to H_{max} and with respect to H. Of course, I don't mean this is a universal interpretation of order in general. It is only a suggestion which may be useful or may not be useful.

  - ☐
- ☐ **Global Summary: (Rough Draft)**
  - ☐ What is being discussed in the article is the relationship of the a self organizing system being dependent on the environment. The energy of the system needs to follow the laws of thermosynamics. Energy and its equilibrium and its expected behavior is being argued as a probability of complexity in a self organizing system.
  - ☐ The linkages not only in the fundamental scales of thermodynamics but to the understanding of the overall system. Self organizations as seen through information can be predicated by______ what are the static members and the unstatic elements of the system. Information can be seen as more bits (information can be measured) But how the bits are distributed and how that relates to the system is the key for there to be a union between the laments introduced. Schrodinger order to order from order to order from noise,
  - ☐ The understanding and the reflection of von Foerster is to discuss that On Self-Organizing systems the entire system is what creates the phenomenon. The close observation of that fact can lead to new insights and associations / investigations to how environment down to the atomic level can influence life at an evolutionary scale at the cellular level. Curently the discorse can be see through the generations of Self-Organizing Systems or can be symbolically redefined as entities that are not really whole.
- ☐ **Final Drafts**

Information Arts: Ch. 3.3 Materials and Natural Phenomena: Nonlinear Dynamic Systems, Water, Weather, Solar Energy, Geology, and Mechanical Motion pp. 234-259 **Links:**

- ☐ _Article Summary:
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
    - ☐ Complexity: en.wikipedia.org–
    - ☐ NonLinear Systems: en.wikipedia.org–
    - ☐ Chaos Theory: en.wikipedia.org–
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
    - ☐ Concepts
    - ☐ Online Sources:
      - ☐ Turbulent Landscapes "Complexity" Section www.exploratoriu
      - ☐ Turbulent Landscape Exhibition www.exploratoriu
      - ☐ Artworks and Artists: www.exploratoriu
- ☐ **_Outline**
  - ☐ **Introduction:** (p. 235)
    - ☐ Since prehistoric times humans have observed natural phenomena. They have watched the heavens and the earth and monitored the flow of the winds and the waters. The spirit of observation has stretched from awe and terror to enjoyment.
    - ☐ The purpose has extended from propitiation to fascination to exploitation to understanding to control.
    - ☐ In modern times, the process of observation has been differentiated into fields such as religion, philosophy, art, science, and engineering. Art, literature, and poetry have always pondered the landscape.
    - ☐ This chapter considers artists who continue this tradition influ- enced by the ideas, insights, and perspectives of contemporary physical sciences. It con- siders artists who are fascinated by nonlinear systems, the mechanics of motion, and geological and solar phenomena.
  - ☐ **Nonlinear Systems** (p. 235)
    - ☐ In the past, science aspired toward a dream of total predictability.
    - ☐ Contemporary scien- tists now accept that some systems are nonlinear.
    - ☐ Complexity and chaos theory study the nature of this predictability.
    - ☐ Some theorists see this area of concern as a radical challenge to traditional physical science; others see it as a fine tuning.
  - ☐ **"Turbulent Landscapes" at the Exploratorium and the InterCommunication Center** (p. 235)
    - ☐ San Francisco's art and science museum, the Exploratorium, mounted an exhibit called "Turbulent Landscapes," which explored the science and art of complex, nonlinear sys- tems.
      - ☐ "Turbulent Landscapes" uses fog, wind, smoke, sand, water, gas plasma, slime mold, and other natural phenomena in ways that are ethereal, beautiful, mysterious, sensual, and playful. Yet, it's also an exhibition that touches on compelling questions about complexity, the emergence of order and disorder in the universe, and our perception of that process.[1]
    - ☐ The focus on nonlinear systems was seen as a possible point of convergence for art and science.
    - ☐ …exhibit offers an "Ideas and Statements" section that emphasizes the search for pattern as a cornerstone of both art and science.
    - ☐ Jim Crutchfield, a complexity researcher at University of California at Berkeley who helped design the exhibit, describes its appeal in making ideas of complexity accessible:
      - ☐ "Turbulent Landscapes" celebrates a new view of nature—a view that, when coupled with recent scientific innovations, allows us to understand much of nature's inherent complication. We now ask: How do simple systems produce unpredictable behavior? And, in a complementary way, how is it that large complicated systems generate order? Most importantly, we are learning how to answer these

questions. It appears that much of what is intricate and highly structured in nature arises from a delicate interplay of order and chaos. All of the exhibits illustrate this, not only in how patterns emerge, but also in our perception of those patterns.[2]

- ☐ Peter Richards, who was curator of the Exploratorium's artist-in-residence program, described the exhibit, the contributions that artists make to the understanding of natural phenomena, and the faith that science and art can learn from each other:
  - ☐ A group of artists working at the Exploratorium have recently completed a body of work that examines those systems in nature that are inherently self-organizing. At a time when scientists finally have large enough computers to study these complex systems, these artists, working here with simple materials, have created works that model these same systems in ways that not only capture the physical essence of this phenomena, but also their essential beauty. Be it the filagree of an a-cellular slime mold, the sensual flow of water over eroding terrain, or the organic nature of a video feedback system, it is the beauty of these phenomena that lead to questions and deeper observations, observations that have led to significant learning experiences for those working in this field, for ourselves and for our visitors.[3]
- ☐ Melissa Alexander, project director of "Turbulent Landscapes," described the special significance of nonlinear theory by quoting from Tom Stoppard's "Arcadia":
  - ☐ The unpredictable and the predetermined unfold together to make everything the way it is. It's how nature creates itself on every scale, the snowflake and the snowstorm. It makes me so happy. To be at the beginning again, knowing almost nothing. People were talking about the end of physics. Relativity and quantum looked as if they were going to clean out the whole problem between them. A theory of everything. But they only explained the very big and the very small. The universe, the elementary particles. The ordinary-sized stuff which is our lives, the things people write poetry about—clouds-daffodils-waterfalls-and what happens in a cup of coffee when the cream goes in—these things are full of mystery, as mysterious as the heavens were to the Greeks. We're better at predicting events at the edge of the galaxy or inside the nucleus of an atom than whether it'll rain on auntie's garden party three Sunday's from now. Because the problem turns out to be different. We can't even predict the next drip from a dripping tap when it gets irregular. Each drip sets up conditions for the next, the smallest variation blows prediction apart, and the weather will always be unpredictable.[4]
- ☐ She notes that science and technology are at last giving us the tools to understand what used to seem chaotic and unpredictable.

- ☐ **Ned Kahn** (p. 237)
  - ☐ "Turbulent Landscapes" included twenty-one of Ned Kahn's sculptures, which explored phenomena such as vortexes of water and smoke, wind currents, rippling sand, squiqqling hoses, and magnetics.
  - ☐ Ned Kahn's statement from the show describes an interest in framing and enhancing the perception of natural phenomena:
    - ☐ The confluence of science and art has fascinated me throughout my career. For the last fifteen years, I have developed a body of work inspired by atmospheric physics, geology, astronomy, and fluid motion. I strive to create artworks that enable viewers to observe and interact with natural processes. I am less interested in creating an alternative reality than I am in capturing, through my art, the mysteriousness of the world around us.

      My artworks frequently incorporate flowing water, fog, sand, and light to create complex and continually changing systems. Many of these works can be seen as "observatories" in that they frame and enhance our perception of natural phenomena. I am intrigued with the way pat- terns can emerge when things flow. These patterns are not static objects, they are patterns of behavior—recurring themes in the repertoire of nature.[6]
  - ☐ Kahn's exhibits are interactive—inviting the viewer to manipulate them for purposes of aesthetic appreciation and/or better understanding of the phenomenon.
- ☐ **Natural Phenomena—Oceans, Water, and Moving Liquid** (p. 239)
  - ☐ To the extent that the artists try to realize some nonstandard movement of water, they must function as engineers and scientists.
  - ☐ **Peter Richards and George Gonzales**
  - ☐ **Paul DeMarinis**
  - ☐ **Other Artists and Projects**

- ☐ ***Stephen Wilson*** created an outdoor event on the beach in which a computer coordinated sound movement to and from the audience with the sensed move- ment of waves and tides.
- ☐ ***Michael Brown*** creates works that build on the flow of water. *Meandering,* which was in the "Sensitive Chaos" show, flows water down an adjustable tilting glass that meanders and reflects like a river.
- ☐ ***Paul Sermon and Andrea Zapp***'s *Body of Water* projected images onto flowing water.
- ☐ ***Sally Weber,*** best known as a hologra- phy artist, created *Threshold of a Singularity—A Memorial,* which uses holography to visually amplify the behavior of water dropping in a pool.
- ☐ ***Lewis Alquist*** created *Fickle Oracle,* which creates a parabolic mirror by spinning a circular basin of mercury on a turntable. Viewers can change the focal length by changing the spin speed.
- ☐ ***Stephen Pevnick*** sculpts fountains with his computerized system for controlling water drops such that text or images can be embedded in the flow.
- ☐ ***Michel Redolfi*** composes music for underwa- ter environments, such as *Sonic Waters,* which broadcast sonar, and *In Corpus,* which monitored the motion of people in a pool.
- ☐ ***Pamela Davis,*** who coordiates art-science programs for UCLA, creates sculptures that explore physical and mathematical concepts, such as the ***Taylor Column,*** which builds its effects based on swirling liquids inside concentric tubes.
- ☐ ***Athena Tacha*** created a series of public installations based on study of water in its various forms including *Ice Blocks, Merging,* and *Chaos* (Fluids).
- ☐ In her *Soft Earth* projects, *Joan Lederman* uses the sediments of various oceans as ceramic glazes.
- ☐ ***Yuki Sugihara***'s *Spiral Water Dome* encloses visitors in a hemispheric space with a thin membrane of water onto which images can be projected.
- ☐ Exploring concepts of transience, ***Andy Goldsworthy*** works with natural forces such as wind and water to create sculptural installations such as his icicle and snow works that are transformed by the elements.

- ☐ **Natural Phenomena—Erosion and Geological Action** (p. 241)
  - ☐ The earth is formed by the action of water, wind, and tectonic activity. Geologists study these forces to understand the earth's past, present, and future. Some artists are similarly intrigued by the processes that created the earth.
  - ☐ **JoAnn Gillerman and Rob Terry**
  - ☐ **Ken Goldberg, Randall Packer, Wojciech Matusik, and Gregory Kuhn**
  - ☐ **Other Artists and Projects**
- ☐ **Natural Phenomena—The Sky, Winds, and Weather** (p. 244)
  - ☐ Introduction:
    - ☐ The sky and the wind are ever present parts of life.
    - ☐ In the past, kinetic artists built wind- activated sculpture.
    - ☐ Sky artists such as Otto Peine created inflatable and balloon-based art.
    - ☐ Any artist trying to work in this unorthodox environment needed to engage knowl- edge of science and engineering related to the sky. New opportunities have been opened up by scientists' use of satellites to study climate and weather. This section focuses on artists interested in phenomena such as the winds and weather.
  - ☐ **Project Taos**
    - ☐ At SIGGRAPH98, the Japanese group Project Taos created a Sensorium installation called *BeWare,* focused on world weather, in which infrared satellite images of a longitudinal slice of the earth's surface were projected onto a long narrow plate. The temperature of places on the plate was correlated with the temperature of the corresponding place on the earth derivable from the infrared data.
  - ☐ **Walter De Maria**

- ☐ Walter De Maria created an extraordinary earth work called *Lightning Field* in an area of New Mexico with high incidence of lightning. The sculpture consists of four hundred stainless steel poles in a rectangular grid array of one mile by one kilometer. Depending on conditions, the poles attract many lightning strikes. The site is maintained by the Dia Foundation, which schedules overnight visits.

- ☐ **Other Artists and Projects**
  - ☐ Artist ***Gene Cooper*** presents performances in which he wires his body up to be stimulated in accordance with lightning strikes using the capability of the NOAA (National Oceanic and Atmospheric Agency), which can record lightning strikes anywhere in the United States.
  - ☐ The German group Art+Com has created TerraVision (T-Vision), which allows a simultaneous real-time view of the whole earth composited from satellite images as an examination of the "decoupling of time and space."
  - ☐ ***Jon McCormick***'s *Four Imaginary Walls* projected 3-D computer animations influenced by current weather conditions.
  - ☐ *Michael Rodemer* created an installation in which fans in West Virginia were linked to wind data in Chicago.
  - ☐ ***Robin Minard*** 's *Weather Station* used weather information to activate a sound installation of 320 piezo speakers.
  - ☐ In *Writing Machine,* ***Patrick Clancy*** created an installa- tion in which pages of text are rearranged based on a combination of sensor readings of the sun and weather and user interactions from the Web.
  - ☐ Japanese architect ***Toyo Ito***'s *Tower of the Winds* reads wind speed and direction to change its lighting.
  - ☐ ***Bill and Mary Buchen*** build sound installations that respond to wind and sun, such as sun catchers, which generate sound and movement of light based on the winds and various kinds of wind instruments such as harps, bows, and gamelans.
  - ☐ ***Guillaume Hutzler, Bernard Gortais, and Alexis Drogoul*** 's *Garden of Chances* presents an abstract computer graphic animation whose mo- tion and color is controlled by real-time weather data from a particular spot in Britain.

- ☐ **Solar Art** (p. 246)
  - ☐ Introduction:
    - ☐ For many scientists, the sun is the most intriguing object in the sky. It is the source of energy for everything on the earth and the center of our local solar system. It is a gateway to understanding the other stars. Artists have pursued a variety of approaches to solar art.
  - ☐ **SolArt Global Network**
    - ☐ Ju¨rgen and Nora Claus organized the international SolArt Global Network to coordinate work of artists, scientists, and theorists whose work was inspired by the sun. It was begun on the summer solstice in 1995. Here is the statement of purpose:
    - ☐ The SolArt Global Network is an international group of artists using solar energy in their artwork. These artists seek to stimulate the global cultural imagination toward use of renewable energy resources. . . .
    - ☐ . . . Examples of solar art are:
      - ☐ -Research-based art penetrating into the deep space of light

        -Solar light works, including mirrors, prisms, and reflections of sunlight -Outdoor holograms using sunlight as a great attractor

        -Light work depending on direct use of solar power by photovoltaics[8]
    - ☐ Ju¨rgen Claus sees the transition to solar energy as an absolute ecological necessity. He notes that the change will not happen without underlying cultural changes, and sees artists who understand solar energy as a critical element in bringing about that change. Claus creates sculptures that use solar energy.
  - ☐ **Robert Mulder and Kristi Allik**

- ☐ Robert Mulder and Kristi Allick are sound artists who have produced many installations and performances. Their projects are often part of larger events, such as the *Millennium Project,* designed to increase the public's awareness of environmental issues. *Skyharp* is an installation performance that senses environmental forces, such as the wind and sun, and uses that information to shape sound events:
- ☐ *Skyharp* is a virtual instrument designed to analyze and extract (by means of a video camera and computer system) dynamic information from a natural environment. With this information a multi-channel electro-acoustic texture is generated which is subsequently played back via twenty or so specially constructed "tube speakers" that are placed among the natural constituents of the outdoor environment. The name Skyharp reflects the aesthetic function of the installation; it is a composition that is "played" by elementary ecological forces, such as the wave action of water, the broad sweeping and subtle fluttering movements of the trees, the revolving motion of clouds, and the imperceptibly slow creeping of light and shadow. In the "hands" of these sources a haunt- ingly beautiful soundscape is created which harmoniously complements the incipient source.[9]

- ☐ **Arts Catalyst—Eclipsing the Millennium**
  - ☐ Arts Catalyst, the British arts-science group, created a major event that used the eclipse visible in Europe in 1999 to look at the ways in which scientists and artists explore solar events.
  - ☐ Scientists will be able briefly to study the effects of the solar wind: clouds of subatomic particles which emanate from the sun and sweep past us to the edge of our planetary system. . . . The Arts Catalyst is planning a sequence of science-art projects in 1999, the year of the eclipse, to mark this significant cosmological event and contemplate humanity's complex and changing rela- tionship with the cosmos . . .

    The phenomena of the total eclipse for me [artist Anne Beam] represents a strange para- dox where, although we can rationally explain so much of our universe, there are still some phenomena, large and small, which retain the power to overwhelm, exhilarate, and transcend reason.[10]
- ☐ **Other Artists and Projects**
  - ☐ ***Sculptures***
  - ☐ ***Installations and Performances***
- ☐

- ☐ **Mechanics—Oscillation and Pendulum Action** (p. 251)
  - ☐ **Norman Tuck**
    - ☐ Norman Tuck creates large kinetic sculptures out of everyday materials, surplus, and electronic components. Typically whimsical, they use the basic principles of physics and mechanical engineering to create amazing events.
  - ☐ **Other Artists and Projects**
    - ☐ ***Anna Valentina Murch***'s *Chaotic Chains* is a kinetic sculpture that explores the forms made by chains of mirrored balls suspended from the ceiling and attached at the bottom to motor shafts. A flashing strobe catches the evolution of the motion, from regular to chaotic.
    - ☐ In the pendulum painting *Nothing, Magnified* ***Thomas Shannon*** creates work based on paint dripping from a moving pendulum.
    - ☐ ***Archimedia*** created the *Audio Pendu- lum* project for a Helsinki, Finland, public art project in which video images of each pendulum were converted into sounds within a particular part of the sound spectrum.
    - ☐ ***The Soda Group*** created a popular Java Web event called *Constructor,* in which visitors can control the movements of animated objects via changes in parameters such as gravity and friction. (See chapter 5.2 for other artists working with kinetics.)
- ☐ **Fire, Heat, Magnetics, and Electromagnetics** (p. 253)
  - ☐ **Artists and Projects**
    - ☐ ***Takis*** was famous for his introduction of magnetic forces into sculpture as a reference to invisible and mysterious forces.
    - ☐ ***David Durlach*** choreographs magnetic dust and fluids through the computer control of underlying electromagnets.

- ☐ ***Heather McGill and Stan Axelrod*** 's *Magnetic Field Patterns* allows users to manipulate fluids into "impossible shapes" by moving magnets.
- ☐ ***Nick Bertoni and Maggi Payne***'s *Flame Speaker* uses the ionized gas of a flame to function as a speaker.
- ☐ ***Bill Parker***'s *Turbulent Business* investigates electrified plasma gas that puts out mini lightning bolts wherever the viewer's finger touches a surrounding glass dome.
- ☐ ***Juanita Miller***'s *Point of Criticality* explores the phenomenon of critical change points found in many natural events: "A large pile of sand or grain is a self-organizing system in the way that particles fall and fit together, resting on top of one another. If they are allowed to pile onto a space with no sides they form as high as they can given their shape and weight. . . . When the pile reaches a height that is no longer sustainable it avalanches."
- ☐ Responding to the aurora magentic storms, ***Catherine Richards*** sculpted *Cabinet,* a completely electromagneti- cally isolated enclosure built out of copper-clad elements inspired by scientific appartus of the nineteenth century.
- ☐ ***Mario Ramiro*** has created a series of gravity-defying sculp- tures using electromagnetic levitation and thermal forces.[12]

- ☐ **Materials Science, Rapid Prototyping, and Chemistry** (p. 253)
  - ☐ **Artists and Projects**
    - ☐ ***Materials Science***
      - ☐ ***Jean-Marc Philippe*** sculpts with nickel-titanium shape-memory alloys that change their shape with seasonal and diurnal temperature changes.
      - ☐ ***Richard Lerman*** constucts wound installations with piezo ceramic sound transducers.
      - ☐ ***Yves Kleine***'s *Octofungi* sculpture uses silent-shape metal as its kinetic infrastructure (see chap- ter 5.3).
      - ☐ ***Ted Krueger*** explores the idea that new materials will be critical in the future of architecture by building interactive shape-metal sculptures (see chapter 5.4).
      - ☐ ***Evelyn Rosenberg*** developed a "detonographic" method of using explosives to fuse metal with other carved elements.
      - ☐ ***ibeke Sorensen,*** known for her animation and interactive media works, has collaborated on several scientific projects to develop new display technologies.
      - ☐ In *Chemical Painting*, ***Ronald Warunek*** created images by arranging for specially mixed chemicals and pigments placed between plates to be subjected to electromagnetic and temperature manipulation.
      - ☐ In works such as *Contingency* and *Indeterminancy,* ***Dove Bradshaw*** carefully selects materials and chemicals to put together to unleash physical processes of reaction and transformation.
      - ☐ ***Toshiya Tsunoda***'s installation *Monitor Unit for Solid Vibration* created a sound event of out of sensors monitoring the vibrations given by the materials and structures of the Tokyo Opera City building.
    - ☐ ***Rapid Prototyping***
      - ☐ ***Michael Rees*** has created many sculptures using RP techniques. In one paper he characterized his work with the technologies as playing "in what medieval alchemists called the Albedo state, the silvery mercurial state where one thing can reflect or become another as easily as not."
      - ☐ ***Eva Wholgemeuth*** used the data map of her body to create stereolithographic *Evadolls*.
      - ☐ ***Derrick Woodham*** organized the Intersculpt99 conference which invited sculptors to submit their work for display in a VRML (virtual reality modeling language) exhibition space and offered to generate rapid prototype models of some of the works for an accompanying gallery show.

- ☐ Using rapid proto- typing techniques, artists ***Masaki Fujihata, Michael Rees, Keith Brown, Peter Tere- zakis, and Arghyro Paouri*** have created sculptures from synthetic computer models.
- ☐ ***Stewart Dickson*** built sculptures from stereolithographic renderings of abstract mathe- matical forms.
- ☐ ***Christian Lavigne*** wrote an article "La sculpture numerique," which reviewed digital sculpture, including rapid prototyping experiments.
- ☐ Boston's ***CyberArts*** organized the "Mind into Matter" show of artists working with rapid prototyping tech- nology, including ***Tim Anderson, Jim Bredt, Dan Collins, Bill Jones, Michael La- Forte, Christian Lavigne, Denise Marika, and Michael Rees. Sheldon Brown***'s *Istoria* is creating three relief-sculpted panels built by rapid prototyping technologies that derive the images from 3-D databases. The databases are collected from immovable dwellings around the world such as the temporary shelters of Mexicans preparing to move across the border or environments created by homeless people underneath Tokyo's Shinjuku subway station.
- ☐ ***Tom Longtin*** uses rapid prototyping processes to build organic-looking parts from computer files.
- ☐ ***Dan Collins*** at Arizona State University creates virtual sculptures and directs a research project to support artistic RP experimentation.
- ☐ ***Andrew Werby,*** a sculptor using RP technologies, maintains a 3-D sculpture Web site with links to technologies and artists.
- ☐ ***Richard Collins*** maintains an extensive *Rapid Prototyping for Sculptors* Web site with links to art work and explanations of the technology.

- ☐ **Summary: Pattern Finding and Poetry of Matter** (p. 256)
  - ☐ **Pattern Finding:**
    - ☐ Artists and scientists look for patterns. For a long time both fields concentrated on the visible world. Both found power in their portrayal of what they held to be the underlying patterns of nature.
    - ☐ Now that simple formula is under assault. Scientists focus on nonvisi- ble phenomena and examine patterns such as nonlinear systems that are not so obvious to the uninstrumented observer.
    - ☐ Kahn noted his interest in human-pattern finding and the critical importance of surprise in his identification of the themes and designs of works. Crutchfield noted a similar factor in scientific research. They also discussed the interplay of pattern and ambiguity, and both suggested that exploration of these phenomena still holds appeal even in the con- temporary world. Here are some excerpts:
    - ☐ *NK* [*Ned Kahn*]: People project all kinds of patterns and associations into these systems, but that's what makes it art. Artists try to create things that are ambiguous, things with many levels of meaning for people to impose their patterns on. . . .
    - ☐ *JC* [*Jim Crutchfield*]: There's a threshold beyond which there's so much ambiguity that people won't see any structure. This must be the hardest part in creating the exhibits, to play against too much ambiguity. Things that are seemingly structureless are uninteresting. At the other end of the spectrum, a completely straightforward, obvious statement of fact is not engaging. Interest- ing-ness increases—human interest increases—as you increase the ambiguity. Things in the world that are really intriguing draw you in. Initially, at least, if you're a little uncertain about what you'll see, they're ambiguous. Then the structure is revealed and you begin to see patterns.[13]
      - ☐ Kahn observed that his engagement of an audience to ask ques- tions of nature is similar to the way that scientists ask questions of nature:
      - ☐ *NK:* I've tried to create things that are about what's happening right in front of you, right now. My work has been heavily influenced by practicing Buddhism over the last twenty years. The essence of it is a kind of exercise with your mind, exercises designed to make you aware of what's happening right in this moment. The goal is to be cognizant of all the sensations you're experiencing, hearing, and seeing, and feeling, even the mind's activity itself; all of the mind's tendencies of thinking and analyzing and planning and remembering things. The practice is to not get lost in the mind's

wanderings. . . .

NK: There is an analogy to what scientists do. Certainly not all, but a lot of science is basically asking a question of nature. That is what I am doing. Putting a frame around a system and letting it unfold through its own dynamics. Letting it create the pattern, letting nature sculpt itself to a pattern. Rather than chiseling it myself or painting it into a pattern, I try to let nature be the composer.

- ☐ **Bits vs. Atoms—The Future of Phenomena-Based Art** (p. 258)
  - ☐ Nicholas Negroponte's book *Being Digital* promotes the idea that the manipulation of bits (information) is replacing the manipulation of atoms (physical stuff) in many realms of life.
  - ☐ The "Sensitive Chaos" show, which was similar to "Turbulent Landscapes," presented at the ICC gallery in Tokyo, also explored physical-world phenomena.
  - ☐ The science-and-art writer and curator Itsuo Sakane eloquently noted the importance of artists continuing to explore natural phenomena even as the world moves toward bits:
  - ☐ "Sensitive Chaos" is a symbolic expression applied by the eighteenth-century poet Friedrich Leo- pold Novalis to water. Here it is a metaphor not just for water, but for all those entities which, while metamorphosing through a variety of time-spans, change their shape and harmonize the pulse of the universe with the vibrations of the earth.

    As the information society moves faster and faster, we are inundated with a proliferation of purely symbolic and virtual images. And while art and science approach one another more and more closely, we are always surrounded by these superficial concepts, and the present fin de sie`cle feeling scatters and betrays us. Couldn't we at least have an exhibition rediscovering the dialogue with natural phenomena that was the origin of both art and science? Can't we have a return to innocence, a poignant memory of our unity with all existence? That is precisely what we hope to achieve with this exhibition.

    In place of high-tech and ultramodern creations, here we have artworks of a kind that have moved mankind since time immemorial, and excited his aesthetic sense and curiosity. Natural phenomena like water, sand, and air that have nurtured the flower of science, the simple process of crystallization, the innumerable vibrations and movements that make us feel the rhythm of earth and space, are here in profusion. Moreover, the artists here today, just like scientists, all feel the mystery of the hidden principles underlying existence, and are capable of an expression that can be felt with the five senses. The hard and fast line dividing art from science is already gone. . . .

    While the overwhelming tendency of contemporary media art is to move from the atom to the bit, this school of artists must surely take it upon itself to bring about the coexistence of bit and atom, which will become more and more necessary to the next generation. They must become catalysts for a new consciousness of the interplay between bit and atom. It's summer. Isn't this the season for people to recall the past, and return to commune with space and spirits with water as a catalyst?[14]
- ☐ **Notes:**
  - ☐ 1. Exploratorium, "'Turbulent Landscapes' Statement," ⟨www.santafe.edu—CompMech papers/TurbLand.html⟩.

2. J. Crutchfield, "Ideas and Statements," ⟨www.exploratorium.edu—t.landscapes⟩.

3. P. Richards, "Curatorial Statement," ⟨www.exploratorium.edu—t.landscapes⟩.

4. T. Stoppard, "Arcadia," quoted in M. Alexander, "Curatorial Statement," ⟨www.exploratorium.

edu/t.landscapes/⟩.

5. M. Alexander, "Curatorial Statement," ⟨www.exploratorium.edu—curatorial.html⟩.

6. N. Kahn, "Artist Statement," ⟨www.exploratorium.edu—artworks.html⟩.

7. Exploratorium, *Wave Organ* Project Description, ⟨www.exploratorium.edu⟩.

8. J. Claus, "SolArt Art Network Description," ⟨mitpress.mit.edu—solart solartHome.html⟩.

9. R. Mulder and K. Allik, "*Skyharp* Description," ⟨www.aracnet.net~rmulder/⟩.

10. Arts Catalyst, "Eclipse Project Description," ⟨www.artscat.demon.co.uk⟩.

11. Exploratorium, "Norman Tuck Exhibit," ⟨www.exploratorium.edu⟩.

12. M. Ramiro, "Between Form and Force," *Leonardo,* vol. 53(1998):4.

13. Exploratorium, "'Turbulent Landscapes' Discussion, Kahn-Crutchfield," ⟨www.santafe.edu projects/CompMech/papers/TurbLand.html⟩.

14. I. Sakane, "'Sensitive Chaos' Curatorial Statement," ⟨www.ntticc.or.jp—index e. htm⟩.

- ☐
- ☐
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- ☐ Global Summary:
  - ☐ The article discussed the opportunities with Non linear systems. And the links between artists and scientists interested in natural systems. Nature as a force for inspiration and to same what is chaotic and finding order from the signals / data. The bit and the ego are united conceptually through information. This section is declaring that the materiality of the universe is fundamental to the Atom. All artists in this section use nature as a parameter to either create a dynamic system or to use it as a metaphor to flow other mediums through (information)
  - ☐

On the Purpose: An Enquiry Into the Possible roles of The Computer in Art pp. 1- 8 (1973) **Links:**

- ⊟ _Article Summary:
  - ☐ On the Purpose: An Enquiry Into the Possible roles of The Computer in Art
  - ☐ Author: Harold Cohen
  - ☐ pp. 1-8 (08)
  - ☐ Year:
  - ☑ Publisher:
- ☐ _Bibliography:
  - ☐ Cohen, Harold. “On Purpose: An Enquiry Into the Possible Roles of the Computer in Art.”

    Center for Research in Computing and the Arts. 1973. University of California, San Diego. Dec. 2004 crca.ucsd.edu—onpurpose.pdf.
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
    - ☐ Concepts
    - ☐ Online Sources:
- ⊟ _Outline
  - ⊟ **Page 01**
    - ☑ The development of the computer has brought with it a cultural revolution of massive proportions, a revolution no less massive for being almost silent.
    - ☐ We are living now in its early stages, and it would be difficult to predict - certainly well outside the scope of this article - what changes will be effected within the next two or three decades.
    - ☐ the computer will have come to be regarded as a fundamental tool by almost every conceivable profession.1
    - ☐ The artists may be among them. That will be

      the case, obviously, only if it shows itself to have something of a non-trivial nature to offer to the artist; if it can forward his purposes in some significant way.
    - ☐ …I have come to believe, through my own work with the machine, that there may be more fundamental notions of purpose, and a more fundamental view of what the machine can accomplish, than we have seen so far;
    - ☐ Speculation is cheap, of course, as the popular media have shown. If you fantasize any given set of capabilities for the computer, without regard to whether the real machine actually possesses them, then you can have it achieving world domination or painting pictures, falling in love or becoming paranoid; anything you wish. I would hope to offer something a little more rigorous, if rather less romantic.
    - ☐ …I propose to proceed by describing the machine's basic structure and functions, and by giving a simple account of programs of instructions which it can handle

      with those functions. It should not prove necessary to make any speculation which cannot be stated in terms of these.
    - ☐ the significance of the question would seem to point to the notion of Purpose rather than purposes, implying, if not a hierarchical structure with Ultimate Purpose sitting on top as its informing principle, certainly a structure of some sort which relates all of an artist's individual purposes.
    - ☐ The chain of interrogation: Why did you paint this picture blue ? Why did you paint

      this picture ? Why do you paint ? is thus a good deal less innocent than it might seem at first glance.
    - ☐ I suspect that the notion of Ultimate Purpose enjoys little currency today: but then it must follow that Purpose is not to be arrived at by backtracking up a hierarchical structure from the things that an artist does, much less from the objects he makes.
  - ☐ **Page 02**
    - ☐ The problem is rather to propose a structure which can be seen, as a whole, to account for the things the artist does. The notion of Purpose might then reasonably be thought to characterize that structure, as a whole.
    - ☐ In what terms, then, would it be possible to maintain that the use of the computer might ‘advance the artist's Purpose' ?
    - ☐ Any claim based upon the evidence that 'art' has been produced would need to be examined with some care, and in the absence of any firm agreement as to what is acceptable as art we would probably want to see, at least, that the 'art' had some very fundamental characteristics in common with what we ordinarily view as art. This could not be done only on the basis of its physical characteristics: merely looking like an existing art object would not do. We would rather want to see it demonstrated that the machine behavior which resulted in the 'art' had fundamental characteristics in common with what we know of art-making behavior.
    - ☐ it must be clear that my definitions have much in common with the curious way in which we ordinarily make our definitions of art.
    - ☐ We would probably agree, simply on the evidence that we see around us today, that the artist considers one of his functions to be the redefinition of the notion of art2. Or we might say that the artist uses art in some way to redefine, i.e.

modify himself. But since he is the agency which is responsible for the art process which effects the modification, we could restate this: the artist who uses art to modify the artist who uses art to modify....

- ☐ These are recursive3 structures. I think it will become evident in due course that my definition of Purpose is recursive also; and the balance of this article may suggest that it has, in fact, been generated by my use of the machine.
- ☐ For the moment, though, I propose to adopt the earlier position, and to argue that the machine behavior shares some very fundamental characteristics with what we normally regard as art-making behavior.
- ☐ …remains reasonable to talk about 'the machine' because, big or small, fast or slow, all computers do much the same things, and consist, diagrammatically at least, of the same parts.
- ☐ Part of it, usually called the Input/Output Unit, lakes care of its communication with the world outside itself.
- ☐ Part, as you probably know, is used for storage – it is the computer's 'memory.' like alphabetic characters, colors or instructions.
- ☐ The 'operations room' of the whole machine, appropriately enough called the Central Processing Unit (CPU), is concerned with the processing of the stuff the machine handles, and for shifting this stuff around inside the machine.
- ☐ If you think of 'memory' as a very long string of numbered boxes, or cells, then the CPU looks after the business of storing things in the cells, labeling the cells, keeping up an index of where all the labels in use are to be found, retrieving the contents of cells with particular labels, and so on.
- ☐ The computer is a general-purpose symbol-manipulating machine, and it is capable of dealing with any problem which can be given a symbolic representation.
- ☐ If its accelerating use in our society rests upon its remarkable versatility, then its versatility rests in part upon the fact that a very large number of problems - much larger than you might suspect - do indeed lend themselves to symbolic, even numerical, representation.
- ☐ The on-off switch might not seem too promising as a device for counting, since it can only record 'zero' - off, or 'one' - on.
- ☐ ..our own ten-position- switch system pretty limiting also.
- ☐ Whatever 'base' you use for counting, how high you can count depends upon how many switches - each with the 'base' number of positions - you put together. When the 'base' is two, you will need large number of switches to get very far, but each of them need only have two positions - on or off: obviously an ideal situation for counting electrically.
- ☐ If you were to take a somewhat less metaphorical look at those little cells in the computer's memory, you would see that each one was in fact a string of switches. Most small modern computers have adopted sixteen as a standard, though not all: and you can figure out that this sixteen-switch cell - or 'sixteen-bit word', to use the jargon - will be able to hold any number up to 2^{16} - I. In a very rough sense, the size of the machine is measured by how many of these words it has in its memory, and its speed by how long it takes to retrieve one. There would probably be between four and thirty-two thousand sixteen-bit words in a

  small machine: up to a quarter of a million sixty- four-bit words in a big one.

- ☐ **Page 03**
  - ☐ The Central Processing Unit is responsible for moving these words around, and for performing certain operations upon them. Ingeniously, it knows from the words themselves what it is to do, since several bits of each word are actually reserved for instruction codes.
  - ☐ Thus part 'A' of a word might tell the CPU,

    'put the number shown in part "B" into

    memory'; or, 'get the number which is in the

    cell in memory specified by the number in part "B" '; or, 'add the number in part "B" to the number you are now holding, and put the result back in memory'. A machine might recognize and act upon as many as fifty or sixty such instructions, but in fact most of them will be concatenations of simpler instructions, like 'add', 'subtract,' 'multiply,' 'divide,' 'compare,' 'move this into memory,' 'move this out of memory.'
  - ☐ The user sees nothing of all this going on. Sitting in the outside world, the set of instructions he composes for the machine will almost certainly be written in a 'higher level' language, like Fortran or Algol, and before the machine can execute that program of instruction it must first run a program of its own to translate it into its own numerical code.
  - ☐ A single line of code - a 'statement' - in any higher-level language will normally break down into a large number of machine instructions, and these are executed electronically, literally by switching electrical currents, with consequent speeds measured in millionths of a second per instruction.
  - ☐ Yet the computer's phenomenal speed is probably less significant in accounting for its versatility than the fact that it can break down any user's program into the same instruction set.
  - ☐ While the machine is running a user's program it can't do anything else, so that you might say the machine is identified by the program.
  - ☐ But it can take on a new identityin the time it takes to clear one program from memory and load a new one, and in a single day a moderately sized computer installation may run a thousand different programs. Athousand different tasks, a thousand 'different' machines.
  - ☐ The man-machine relationship I am describing here is a very curious one, and not quite like any other I can think of. Nor is it possible to deal meaningfully with questions relating to what the machine can do except in terms of that relationship.
  - ☐ It is true that the machine can do nothing not determined by the user's program; that the program literally gives the machine its identity. But it is true also that once it has been given that identity, it functions as independently and as autonomously as if it had been built to perform that task and no other. Whatever is being done, it is being done by the machine.
  - ☐ For the computer this outside world consists of any or all of a large number of special purpose devices to which it may be connected through its Input/Output Unit, varying widely in their functions from typing or punching cards, to monitoring heart beats or controlling flow- valves. Some of these 'peripheral' devices serve the computer in the very direct sense that

they provide communication channels to the user, allowing him both to get his program into the machine and receive its response to it.

- ☐ Several peripherals function as extra memory for the machine, but then memory simply means storage,
- ☐ Once a program has been entered via the teletype or the card reader, the computer can permanently record it in any of these media, and reload it from them when required to do so. Obviously, these media can be used also for storing large quantities of information.

- ☐ **Page 04**
  - ☐ In general, you might say that the computer may receive messages from any device which is capable of putting an electrical voltage on a line, and may control any device which can be switched by a change in voltage generated by the computer.
  - ☐ The user today has a host of peripherals at his disposal, covering a wide range of sophisticated abilities: perhaps for that very reason it is important to recognize that the use of more sophisticated peripherals does not necessarily imply more sophisticated use of the computer.
  - ☐ If you wanted to make an animated sequence, say of a cube revolving in space, then a television-like device which could display individual frames at the rate of thirty per second would have much to commend it over a mechanical device like a plotter, whose pen only moves at five or six inches per second as it draws the frames one by one. As far as the computer is concerned, however, the task is to generate a series of views of a cube rotating in space, and it will use literally the sameprogram to do so regardless of what device it is addressing.
  - ☐ Failure to produce significant images arises from lack of understanding, not from lack of machines.
  - ☐ The truth is that it has been, and remains, extremely difficult for any artist to find out what he would need to know, either to use the computer, or even to overcome his certainty that he couldn't possibly do it for himself.
  - ☐ If we are to get past 'computer-art', as I am sure we shall, to art made with the help of computers, it will need to be on the basis of a massive change of mental-set on the part of the artist. 5
  - ☐ Suppose, now, that I have a computer whose abilities are like those I have described. Suppose also that it is connected to a teletype and to a Drawing machine (Fig. 5a, b). Assume that the computer has already been loaded with the program by means of which it will be able to interpret my own instructions.
  - ☐ (My instructions here will not be phrased in any existing 'higher level' language but in a fictitious one designed make clear what is being done. In fact I will describe programs diagrammatically, by means of what are known as 'flow-charts', rather than in the line-by-line form required by every language.)
  - ☐ Let's try something a bit more complicated: this time, when I have loaded the

    program and type 'RUN', the machine will get the I it has just put in the cell labeled

    COST, square it, store the result in BOX3, and then print out that result. But then, instead of stopping, it will add I to the l already in COST, and go through the whole cycle again, printing out 4 this time, and then 9,16,25, and so on until it has completed the ten re-iterations called for.
  - ☐ This is pretty simplistic, of course involving a lot of unnecessary PUTting and GETting into and out of memory.
- ⊟ **Page 05**
  - ☑ …the important thing here is the level of generality, since the program will now work for whatever values we put in the cells labeled LENGTH and WIDTH.
  - ☐ No doubt the introduction of this sort of technique for drawing curves into 'computer art' owes much to the mathematics-oriented programmer, who would tend to view a curve essentially as the graph of a mathematical function.
  - ☐ But not all curves can be handled in this somewhat simplistic way, and artists wishing to handle more complex curves have been obliged mostly to use an entirely different approach, if anything even more simplistic.
- ☐ **Page 06**
  - ☐ It may not be clear why anyone would want to use such elaborate means to reproduce a drawing he has already made. The answer is that quite a lot of things can be done to the drawing by suitable programs. Not only can it be reduced, enlarged, shifted, rotated, squashed up, pulled

    out (Fig. 9): it can also be transformed as if

    it were drawn on a sheet of rubber which was then stretched in various irregular ways. None of these operations, or transformations as they are called, is difficult to program, and since they can be applied to any set of points whether
  - ☐ For our purposes, however, the question to be asked is whether the notion of a picture processor, operating upon some previously generated image, corresponds in any useful way to what we know of human art-making behavior. I think the answer has to be that it does not.
  - ☐ To achieve that correspondence, the machine would need to generate the image, not merely to process it.
  - ☐ Intuitively, it seems obvious that the human process involves characteristics which are quite absent from these procedures, and in particular I think we associate with it an elaborate feed- back system between the work and the artist; and dependent upon this system are equally elaborate decision-making procedures for determining subsequent 'moves' in the work. Our enquiry might reasonably proceed by examining whether the machine is capable of simulating these characteristics.
  - ☐ I must explain that the computer possesses one significant ability which was implied by the earlier examples but never explicitly stated. It is able to compare two things, and on the basis of whether some particular relationship holds between them or not, to proceed to one of two different parts of the program. In practice this primitive decision-making device can be built into logical structures of great complexity, with the alternative paths involving large blocks of program, each containing many such conditional statements, or 'branches',
  - ☐ …There is an overall plan - to reach a destination - which breaks down into a succession of sub-plans, which are in turn responsible for generating a series of single movements. But if an 'emergency' is signaled, the current sub-plan is abandoned, and a new one set up.

On the Purpose: An Enquiry Into the Possible roles of The Computer in Art pp. 1- 8 (1973) **Links:**

- ☐ **Page 07**
  - ☐ …How does the program 'decide' on new factors for each new sub-phase ? The ranges permissible for each factor are precisely determined in relation to what the range was last time, indicating another level of feedback. Within that range, the machine makes a random choice.
  - ☐ There seems to be so much popular misunderstanding about the nature of randomness that a word might be said on the subject before going further.
  - ☐ Contrary to popular belief, there is no way of asking the machine to draw 'at random', and if you try to specify what you mean by drawing 'at random' you will quickly see that what you have in mind is a highly organized and consistent behavioral pattern, in which some decisions are unimportant provided they are within a specified range of possibilities.
  - ☐
  - ☐ *This is characteristic of directed human behavior: if you plan to rent a car, you will probably be concerned that it should be safe, that its size and power will be appropriate to your needs. You probably won't care too much what color it is, and in being prepared to take whatever comes you are making a 'random choice' of color: although you probably know it isn't likely to be iridescent pink, matte black, or chromium plated. The same might be said - though with much narrower limits - of the painter who tells his assistant to 'paint it red'; or indeed the painter who uses dirty brushes to mix his paint. They are all examples of making a random choice within specified (or assumed) limits.*
  - ☐ They are all examples of making a random choice within specified (or assumed) limits. In fact the computer generates random numbers between zero and one, which must then be scaled up to limits specified by the user's program.
  - ☐ *You might consider that, in human terms, these limits will be narrow where precise definition is required, wide where it is not. For the computer, the existence of limiting ranges rather than specified values will result in the possibility of an infinite number of family- related images being produced rather than a single image made over and over again. There might be some difficulty in demonstrating the case to be otherwise for the artist.*
  - ☐ While it would seem obvious that any complex purposeful behavior must make use

    of feedback systems, there is no suggestion that such systems alone can account adequately for the behavior. Moreover the ability to satisfy some given purpose, as the 'freehand'line generator does in homing on its destination, accounts for only slightly more.
  - ☐ Moreover the ability to satisfy some given purpose, as the 'freehand' line generator does in homing on its destination, accounts for only slightly more.
  - ☐ The formulation of the purpose is something else: and we would expect to find in human art-making behavior not only a whole spectrum of purpose-fulfilling activities, but also a spectrum of purpose- formulating activities.
  - ☐ If I am to pursue my enquiry, I must now try to demonstrate the possibility of such a structure occurring in machine behavior, although the strategies employed within the structure may or may not correspond to the strategies the artist might employ.
  - ☐ This program is one of a series in which the principal strategy is devised in relation to an 'environment' which the program sets up for itself. An example would be one in which the program first designs, and then runs, a maze: the resultant drawing being simply the path generated by the machine in performing the second part.
  - ☐ An example would be one in which the program first designs, and then runs, a maze: the resultant drawing being simply the path generated by the machine in performing the second part.
  - ☐ For example, the number of cells in the grid and the number and type of distributions of the digits are both critical factors in determining the complexity of the drawing.
- ☐ **Page 08**
  - ☐ What I have described as being controlled by the executive is, in a very general sense, the purpose-formulating mechanism for the 'freehand' line generator, the structure that determines where the lines are to be drawn. You might say that I am the purpose-formulating mechanism for the program as a whole, but the executive program makes my own part in the process rather more remote, if no less significant.
  - ☐ In fact, I doubt whether the main program will be changed much at this point, since what is at stake for me is not what it does, but what determines what it does.
  - ☐ As it reaches each destination, the machine has to choose between anything up to twenty- five next destinations, depending upon the state of the drawing….the character of the resultant drawings would vary enormously as the machine exercised one 'preference' rather than another, but in fact I am suggesting something more complex than simply switching 'preferences'.
  - ☐ Suppose, rather, that the machine exercises its whole range of 'preferences' by scoring each possible destination for its ability to satisfy each preference, and taking the destination with the highest total score as its choice. It might then choose the destination which was relatively far away, didn't involve too much deviation from the current direction, and was in an area of high activity quite close to the center of the drawing. I think this would be a much closer simulation of the way in which human preference-structures are exercised.
  - ☐ Let us go one step further, and suppose the machine to be capable of weighting its scores for its different 'preferences', and of modifying these weightings itself. This possibility is by no means speculative: readers familiar with the development of the field of Artificial Intelligence will recognize its similarity to Samuel's now classic program for a checkers-playing machine (1959)
  - ☐ We might recognize a significant difference between applying a learning program of this sort to successful game playing and doing so to successful art-making.
  - ☐ …Of course the difficulty is ours, not the machine's: since we ourselves would be in some doubt as to the nature of the criteria towards the satisfaction of which the machine might aim.
  - ☐ Art is not a deterministic game like checkers, to be won or lost by the 'player';
  - ☐ ...and though we acknowledge, empirically, that some artists are 'better' than others, that some artists do improve, the problem of formulating general criteria for improvement may be no different in relation to the machine than it is for the

teacher in relation to the art student. It is probably reasonable to assume that there do exist criteria at levels even more remote from the work than any I mentioned: in which case we should be able to formulate them and the machine should be able to satisfy them. But there remains the suspicion that satisfactory performance in art is not to be measured solely by the satisfaction of explicit criteria, and would still not be so no matter how far back one pushed.

- ☐ As to those explicit criteria: there would seem little reason to deny that the machine behaves purposefully at every level described. Yet no level defines its own purpose.
- ☐ …it seems to me that pushing back along the chain of command - either for the machine or for oneself - is less like climbing a ladder than it is like trying to find the largest number between zero and one: there is always another midway between the present position and the 'destination'.
- ☐ It should be evident, then, that I do not consider 'serving the artist's Purpose' to be equivalent to 'talking over the artist's Purpose', or identify the machine with the artist.
- ☐ It should be evident, then, that I do not consider 'serving the artist's Purpose' to be equivalent to 'talking over the artist's Purpose', or identify the machine with the artist.
- ☐ Since under other circumstances these processes too would be played out by the artist, I am also identifying playing-out with the computer with playing-out without the computer.
- ☐ For the machine to serve his Purpose the artist will need to use it as he uses himself.
- ☐ There is no reason to anticipate that the use will be more or less trivial than the use he makes of himself, but every reason to suppose that the structure will change in ways which are presently indefinable.
- ☐ The step by step account of the computer's functions and its programs was intended, of course, to try to demonstrate that the machine can be used in this way.
- ☐ The original question - whether the machine can serve the artist's Purpose - is more redundant than unanswerable, and is in any case not to be confused with asking whether artists might see a need to use it.
- ☐ It is characteristic of our culture both that we search out things to satisfy current needs, and also that we restate our needs in terms of the new things we have found.
- ☐ When it becomes clear to him that the computer is, in fact, an abstract machine of great power, a general purpose tool capable of delimiting his mind as other machines delimit him physically, then its use will be inevitable.

- ⊟ **Notes:**

- ☐ Global Summary: (Rough Draft)
  - ☐ Harold Cohen is explaining his process. His programming and the characteristics and the implied philosophical struggles of how artists can confront computational arts.
  - ☐ Cohen is also citing examples of how computers and embodiment would be programmed if possible. The difference between the reality of the instrument and the procedures of programming the tool to create human behavioral movements. The program can account for many of the movements but without specific examples the intention of the movements would be relegated solely on the logic created by the program.
  - ☐ Cohen describes the drawing program as a substructure that is a byproduct of an actual maze. It does not ever repeat and it is made to generate difference.
  - ☐ Cohen also used the program to create variety and had it autonomously run the parameters and to create a body of work. In so doing the range of difference in size and scale was accounted for. (The program produced 300 drawings in 4 weeks.)
  - ☐ The articles conclusion is that the philosophical implications to computational art is to find what commands are needed to either emulate a behavior or observe the behavior closely and reimplement. The recursive act of programming and the program running its recursive commands leads to complexity that can stand in for artistic intent. Human and computational effort is not as important as the managing and imagining the computational tool being an extension of artistic embodiment.
- ☐ Final Drafts

Space Reader: Heterogeneous Space in Architecture An Introduction to Umwelt pp. 145 - 148 **Links:**

- ☐ _Article Summary:
  - ☐ Space Reader: Heterogeneous Space in Architecture
  - ☐ Author: Michael Hensel, Christopher Hight & Achim Menges
  - ☐ An Introduction to Unwelt pp. 145-148 (Jakob von Uexkull)
  - ☐ Year: 2009
  - ☐ Publisher: Architecture and Design
- ☐ _Bibliography
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
    - ☐ Umwelt — en.wikipedia.org–
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
      - ☐ Kant
    - ☐ Concepts
    - ☐ Online Sources:
- ⊟ _Outline
  - ⊟ An Introduction to Umwelt
    - ☑ Umwelt - Which is constituted by the subjective experience of the surrounding world by the individual organism through its specific senses.
    - ☐ As Peter Sloterjijk argues in his contribution to this volume, this concept effectively defined and continues to determine the spatial concept of the 'environment' and of the organism's relationship to it.
    - ☐ It was also important for the development of systems and information theory, as well as for cybernetic epistemologies.
    - ☐ Uexkull's concept implies that, while environments are shared, the experienced Umwelten are by definition different, based on the organism's configuration of sensory and effective networks.
    - ☐ Because the organisms creates and reshapes its reality by interacting with the world, the Umwelt suggests space may be understood as a reflexively produced and immanent condition of subjective experience, and therefore contrast both with object ideas of space and with phenomenological and Post-Modern concepts that understand it as constructed by the subject.
  - ⊟ Article:
    - ☐ Page 145:
      - ☐ Everyone who looks about in Nature finds himself (or herself) in the centre of a circular island that is covered by the blue vault of heaven. This is the perceptible world that has been given to us, it contains everything we can see. And the visible things are ordered according to their significance for our life.
      - ☐ Everything that is near to us, and has immediate impact on human beings, is there in full size; distant and hence less dangerous things appear small. The movements of the small things may be invisible, while the movements of the things that are close, scare us. When we lie in the shadow of a tree, we are not aware of the imperceptible march of the shadow that is caused by the transit of the distant sun. But every movement of the leaves, caused by the wind or by a bird, is clearly manifested in the shadow outlines.
      - ☐ Things that are invisible to Man because they are concealed by other objects, are revealed to his ear by their sound or to his nose by their smell and, if they come very close, to his sense of touch.

- ☐ Around us is a protective wall of senses that gets denser and denser. Outward from the body, the senses of touch, smell, hearing and sight enfold man like four envelopes of an increasingly sheer garment.
- ☐ This island of the senses, that wraps every man like a garment, we call his Umwelt.

- ⊟ **Page 146:**
  - ☑ It separates into distinct sensory spheres that become manifest one after the other at the approach of an object. For man, all distant objects are sight-objects only; when they come closer they become hearing-objects, then smell-objects and finally touch-objects as well. Finally, objects can be taken into the mouth and be made taste-objects.
  - ☐ Objects, equipped with all the possible sensory characteristics, always remain products of the human subject, they are not things that have an existence independent of the subject. They become 'things' in front of us only when they have become covered by the sensory envelopes that the island of the senses can give them.
  - ☐ What they were before that, before they became covered, is something we will never find out. In this state they are of interest to the biologist only as a cause of stimuli that by their action on the sensory organs make these generate characteristic properties. The purpose of the sensory organs is always to transform stimuli into properties.
  - ☐ Each sensory organ has, as we have seen, a sensory sphere of its own. The sensory sphere of the eye is the most extensive, it extends from the human body to the horizon. The sphere of touch is much smaller, it extends only as far as the feeling hand.
  - ☐ Since the sensory spheres of individual humans are similar in all essentials, the objects in the different Umwelten are also similar.
  - ☐ This has led people to the premature conclusion that objects by themselves are autonomous realities, having an existence of their own, independent of the subject. One can hardly find an educated person who is not prepared to swear that all living creatures experience the same sun, the same moon and the same stars - instead of carefulfy concluding that the celestial objects appear the same only in the Umwelten of our fellow human beings. Even this latter conclusion is wrong, when a small child reaches for the moon; it proves that the moon, barely eight metres away on the child's horizon, is not the same moon that we see. The horizon, that closes off the visible world for us grown-ups at a distance of about six kilometres, has been pushed outwards that far only as a result of various experiences. We have learnt, little by little, to see that familiar objects are not small but remote. Helmholtz tells us that he as a young boy, when standing with his mother in front of the garrison church of Potsdam, asked her to fetch him the small dolls that were repairing the roof of the church.
  - ☐ Among the animals, with their smaller Umwelt horizons, the celestial bodies are essentially different. When mosquitoes dance in the sunset, they do not see our big human sun, setting six kilometres away, but small mosquito suns that set about half a metre away. The moon and stars are absent from the sky of the mosquito.

- ☐ **Page 147:**
  - ☐ No one who has the least experience of the Umwelten of animals, will ever harbour the idea that objects have an autonomous existence that makes them independent of the subjects. The variability of objects is the norm here. Every

object becomes something completely different on entering a different Umwelt. A flower stem that in our Umwelt is a support for the flower, becomes a pipe full of liquid for the meadow spittlebug *(Phi/aenus spumarius)* who sucks out the liquid to build its foamy nest.

- ☐ The same flower stem becomes an upward path for the ant, connecting its nest with its hunting ground in the flower. For the grazing cow the flower stem becomes part of a tasty morsel of food for her to chew in her big mouth.
- ☐ The teachings of the positivists, that are based on the autonomy of objects with a predilection for dealing with sensory delusions of subjects (in order not to admit to the variability of objects), are ostensibly supported by two characteristic peculiarities of human Umwelten: the expansion of space and the placement of the centre of the universe, two closely connected phenomena.
- ☐ No animal will ever leave its Umwelt space, the centre of which is the animal itself. Wherever it goes, it is always surrounded by its own Umwelt space, filled with its own sensory spheres, irrespective of how much the objects change. Man, on the other hand, when he wanders, tends to cut loose the space he moves in from his sensory spheres and thus to extend his paths in all directions. The vault of the sky gets higher and higher and he centre of the world under the heavenly cupola is no longer himself but his home. Man does no longer move with a space that follows him faithfully, as his senses tell him, he moves instead in a space at rest, a space that is cut loose from him and has its own centre. Space has become autonomous as have the objects within it.
- ☐ In the course of the centuries the centre of the ever growing universe has changed its location several times. The geocentric universe, with earth at its centre, was followed, after bitter struggles, by the heliocentric one with the sun as its centre that has persisted to the present day.
- ☐ Kant had already shaken the complacent pOSition of the universe by exposing it as being merely a human form of perception. From there on it was a short step to reinstall the Umwelt space of the individual human being in its proper position.
- ☐ The reason why this step has not to this day been taken, is that the idea of an objective universe, that embraces all living things, is undeniably very useful for ordinary life. The conventional universe, where all our relationships to our fellow human beings are enacted, has brought all personal Umwelt spaces under a common denominator, and this has become indispensable for civilised human beings. Without it, we cannot draw the simplest map, because it is impossible to combine all subjective points of view in a single picture.

- ⊟ **Page 148:**
  - ☑ To draw a map, we must exclude our sensory outlooks and replace them with symbols that can be incorporated into a mental structure. A map is not a picture to be looked at. it is a combination of symbolic signs that have to be learned in order to read the map.
  - ☐ Pastor Busch in Estonia had once sent for a new map of the Baltic provinces and showed it to some peasants. The peasants contemplated the map for a while and then said with a grave nod: 'Very good likeness' - 'Likeness to whom?' asked the astonished Pastor, - 'To the Herr Pastor, of course,' was the answer.
  - ☐ A map is never anything else than an abbreviated description in a conventional sign language. A map can at the most be correct but it can never be a likeness.

- ☐ The peasants did not know the sign language and thus could not read the map. They thought it must be a picture, obviously of the Pastor himself. Since they thought the Pastor was convinced of its likeness, they agreed to this out of politeness.

- ☐ Global Summary: (Rough Draft)
  - ☐ Jakob Uexhull's thesis is that all living things have spheres of senses. The individual combined sphere of senses for an individual being is called an Umwelt. This Umwelt is different for each different entity. This shapes the reality of the animal or human. The perception of each animal can change by species, size, distance and awareness. The senses of each human being can distort the Umwelt depending on the overall awareness of the definition of an object. Example would be the fact of the symbolic nature of a map. If the symbols are agreed upon, then the meaning is validated. Humans can with a shared agreement define the Umwelt beyond the senses. The intellect can distort senses. The conclusion can be that this shared experience can lead to symbolic agreement in all aspects of life.
  - ☐
  - ☐
- ☐ Final Drafts

The NewMedia Reader - 43 Revolution, Resistance, and the Launch of the Web: The Work of Culture in the Age of Cybernetic Systems (Bill Nichols) pp 625-641 (Original Publication 1988) **Links:**

- ☐ **_Article Summary:**
  - ☐ The NewMedia Reader
  - ☐ Author: Noah Wardrip-Fruin and Nick Montfort
  - ☐ 43 Revolution, Resistance, and the Launch of the Web: The Work of Culture in the Age of Cybernetic Systems (pp 625-641)
  - ☐ Year: 2003
  - ☐ Publisher: MIT Press
- ☐ **_Bibliography**
  - ☐ Original Publication

    Screen 21 (1): 22-46. Winter 1988.
- ☐ **_Glossary**
  - ☐ Major Concepts:
  - ☐ Terms
    - ☐ Babyz — en.wikipedia.org–
    - ☐ The Sims — en.wikipedia.org–
    - ☐ Eliza — en.wikipedia.org–
    - ☐ Psychopathology: — en.wikipedia.org–
    - ☐ Extolled — dictionary.referen
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    - ☐ Concepts
    - ☐ Online Sources:
- ⊟ **_Outline**
  - ⊟ **43. [Introduction] The Work of Culture in the Age of Cybernetic Systems**
  - ⊟ **Article:**
    - ⊟ pg. 627
      - ⊟ **Introduction:**
        - ☐ The computer is more than an object: it is also an icon and a metaphor that suggests new ways of thinking about ourselves and our environment, new ways of constructing images of what it means to be human and to live in a humanoid world.
        - ☑ Cybernetic systems include an entire array of machines and apparatuses that exhibit computational power. Such systems contain a dynamic, even if limited, quotient of intelligence.
        - ☐ Telephone networks, communication satellites, radar systems, programmable laser video disks, robots, biogenetically engineered cells, rocket guidance systems, videotex networks—all exhibit a capacity to process information and execute actions. They are all "cybernetic" in that they are self-regulating mechanisms or systems within predefined limits and in relation to predefined tasks. Just as the camera has come to symbolize the entirety of the photographic and cinematic processes, the computer has come to symbolize the entire spectrum of networks, systems, and devices that exemplify cybernetic or "automated but intelligent" behavior.
        - ☐ My intention, in fact, is to carry Benjamin's inquiry forward and to ask how cybernetic systems, symbolized by the computer, represent a set of transformations in our conception of and relation to self and reality of a magnitude commensurate with the transformations in the conception of and relation to self and reality wrought by mechanical reproduction and symbolized by the camera.
        - ☐ This intention necessarily encounters the dilemma of a profound ambivalence directed toward that which constitutes our imaginary. Other, in this case not a mothering parent but those systems of artificial intelligence I have set out to examine here. Such ambivalence certainly permeates Benjamin's essay and is at best dialectical, and at worst, simply contradictory.
        - ☐ Put more positively, those systems against which we test and measure the boundaries of our own identity require subjection to a double hermeneutic of suspicion and revelation in which

we must acknowledge the negative, currently dominant, tendency toward control, and, the positive, more latent potential toward collectivity. It will be in terms of law that the dominance of control over collectivity can be most vividly analyzed.

- ☐ In summary, what I want to do is recall a few of the salient points in Benjamin's original essay, contrast characteristics of cybernetic systems with those of mechanical reproduction, establish a central metaphor with which to understand these cybernetic systems, and then ask how this metaphor acquires the force of the real—how different institutions legitimate their practices, recalibrate their rationale, and modulate their image in light of this metaphor.
- ☐ In particular, I want to ask how the preoccupations of a cybernetic imagination have gained institutional legitimacy in areas such as the law. In this case, like others, a tension can be seen to exist between the liberating potential of the cybernetic imagination and the ideological tendency to preserve the existing form of social relations.
- ☐ I will focus on the *work* of culture—its processes, operations, and procedures—and I will assume that culture is of the essence:

- ☐ **Mechanical Reproduction and Film Culture**
- ☐ Benjamin argues for correspondences among three types of changes: in the economic mode of production, in the nature of art, and in categories of perception.

- ☐ pg. 628

- ☐ At the base of industrial society lies the assembly line and mass production.
- ☐ Technological innovation allows these processes to extend into the domain of art, separating off from its traditional ritual (or "cult") value a new and distinct market (or "exhibition") value. The transformation also strips art of "aura" by which Benjamin means its authenticity, its attachment to the domain of tradition: The authenticity of a thing is the essence of all that is transmissible from its beginning, ranging from its substantive duration to its testimony to the history which it has experienced.[2] The aura of an object compels attention. Whether a work of art or natural landscape, we confront it in one place and only one place. We discover its use value in the exercise of ritual, in that place, with that object, or in the contemplation of the object for its uniqueness. The object in possession of aura, natural or historical, inanimate or human, engages us as if it had "the power to look back in return."[3]
- ☐ One thing mechanical reproduction cannot, by definition, reproduce is authenticity. This is at the heart of the change it effects in the work of art. "Mechanical reproduction emancipates the work of art from its parasitical dependence on ritual" (p. 224). The former basis in ritual yields to a new basis for art in politics, particularly, for Benjamin, the politics of the masses and mass movements, where fascism represents an ever-present danger. The possibilities for thoroughgoing emancipation are held in check by the economic system surrounding the means of mechanical reproduction, especially in film where "illusion-promoting spectacles and dubious speculations" (p. 232) deflect us from the camera's ability to introduce us to "unconscious optics" that reveal those forms of interaction our eyes neglect:

  The act of reaching for a lighter or a spoon is familiar routine, yet we hardly know what goes on between hand and metal, not to mention how this fluctuates with our moods. Here the camera intervenes with the resources of its lowerings and liftings, its interpretations and isolations, its extensions and accelerations, its enlargements and reductions. (p. 237)
- ☐ Objects without aura substitute mystique. In a remarkable, prescient passage, relegated to a footnote, Benjamin elaborates how political practice opens the way for a strange transformation of the actor when democracies encounter the crisis of fascism. Mechanical reproduction allows the actor an unlimited public rather than the delimited one of the stage or, for the politician, parliament. "Though their tasks may be different, the change affects equally the actor and the ruler. . . . This results in a new selection, a selection before the equipment (of mechanical reproduction) from which the star and the dictator emerge victoriously" (p. 247).
- ☐ Alterations like the replacement of aura with mystique coincide with the third major change posited by Benjamin, change in categories of perception. The question of whether film or photography is an art is here secondary to the question of whether art itself has not been radically transformed in form and function. A radical change in the nature of art implies that our very ways of seeing the world have also changed: "During long periods of history, the mode of human sense perception changes with humanity's entire mode of existence" (p. 222).

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- ☐ Mechanical reproduction makes *copies* of visible objects, like paintings, mountain ranges, even human beings, which until then had been thought of as unique and irreplaceable. It brings the upheavals of the industrial revolution to a culmination. The ubiquitous copy also serves as an externalized manifestation of the work of industrial capitalism itself. It paves the way for seeing, and recognizing, the nature and extent of the very changes mechanical reproduction itself produces.
- ☐ What element of film most strongly testifies to this new form of machine-age perception? For Benjamin it is that element which best achieves what Dadaism has aspired to: "changes of place and focus which periodically assail the spectator." Film achieves these changes through montage, or editing. Montage rips things from their original place in an assigned sequence and reassembles them in everchanging combinations that make the contemplation invited by a painting impossible. Montage multiplies the potential of collage to couple two realities on a single plane that apparently does not suit them into the juxtaposition of an infinite series of realities.
- ☐ Montage has a liberating potential, prying art away from ritual and toward the arena of political engagement. Montage gives back to the worker a view of the world as malleable. Benjamin writes:

  Man's need to expose himself to shock effects is his adjustment to the changes threatening him. The film corresponds to profound changes in the apperceptive apparatus—changes that are experienced on an individual scale by the man in the street in big-city traffic, on a historical scale by every present-day citizen. (p. 250)
- ☐ pg. 629
  - ☐ ...By close-ups of the things around us, by focusing on hidden details of familiar objects, by exploring commonplace milieus under the ingenious guidance of the camera, the film, on the one hand, extends our comprehension of the necessities which rule our lives; on the other hand, it manages to assure us of an immense and unexpected field of action. Our taverns and our metropolitan streets, our offices and furnished rooms, our railroad stations and our factories appeared to have us locked up hopelessly. Then came the film and burst this prison-world asunder by the dynamite of the tenth of a second, so that now, in the midst of its far-flung ruins and debris, we calmly and adventurously go traveling (p. 236).
  - ☐ Mechanical reproduction involves the appropriation of an original, although with film even the notion of an original fades: that which is filmed has been organized in order to be filmed. This process of appropriation engenders a vocabulary: the "take" or "camera shot" used to "shoot" a scene where both stopping a take and editing are called a "cut." The violent reordering of the physical world and its meanings provides the shock effects Benjamin finds necessary if we are to come to terms with the age of mechanical reproduction. The explosive, violent potential described by Benjamin and celebrated by Brecht is what the dominant cinema must muffle, defuse, and contain. And what explosive potential can be located in the computer and its cybernetic systems for the elimination of drudgery and toil, for the promotion of collectivity and affinity, for interconnectedness, systemic networking and shared decision-making, this, too, must be defused and contained by the industries of information which localize, condense, and consolidate this potential democratization of power into hierarchies of control.
  - ☐ "Montage—the connecting of dissimilars to shock an audience into insight—becomes for Benjamin a major principle to artistic production in a technological age."[4]
  - ☐ Developing new ways of seeing to the point where they become habitual is not ideological for Benjamin but transformative.
  - ☐ For Benjamin the only recourse is to use those skills he himself adopted: the new habits of a sensibility trained to disassemble and reconstruct reality, of a writing style intended to relieve idlers of their convictions, of a working class trained not only to produce and reproduce the existing relations of production but to reproduce those very relations in a new, liberating form. "To see culture and its norms—beauty, truth, reality—as artificial arrangements, susceptible to detached analysis and comparison with other possible dispositions" becomes the vantage point not only of the surrealist but the revolutionary.[5]
  - ☐ The process of adopting new ways of seeing that consequently propose new forms of social organization becomes a paradoxical, or dialectical, process when the transformations that spawn new habits, new vision, are themselves endangered and substantially recuperated by the existing form of social organization which they contain the potential to overcome.

- But the process goes forward all the same. It does so less in terms of a culture of mechanical reproduction, which has reached a point similar to that of a tradition rooted in Benjamin's time, than in terms of a culture of electronic dissemination and computation.
- We might then ask in what ways is our "sense of reality" being adjusted by new means of electronic computation and digital communication?
- Have cybernetic systems brought about changes in our perception of the world that hold liberating potential? Is it conceivable, for example, that contemporary transformations in the economic structure of capitalism, attended by technological change, institute a less individuated, more communal form of perception similar to that which was attendant upon face-to-face ritual and aura but which is now mediated by anonymous circuitry and the simulation of direct encounter?
- Does montage now have its equivalent in interactive simulations and simulated interactions experienced according to predefined constraints?

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Cybernetic Systems and Electronic Culture

- Simulacra introduce the key question of how the control of information moves towards control of sensory experience, interpretation, intelligence, and knowledge.
- The power of the simulation moves to the heart of the cybernetic matter.
- It posits the simulation as an imaginary Other which serves as the measure of our own identity and, in doing so, prompts the same form of intense ambivalence that the mothering parent once did: a guarantee of identity based on what can never be made part of oneself. In early capitalism, the human was defined in relation to an animal world that evoked fascination and attraction, repulsion and resentment. The human animal was similar to but different from all other animals. In monopoly capitalism, the human was defined in relation to a machine world that evoked its own distinctive blend of ambivalence. The human machine was similar to but different from all other machines. In postindustrial capitalism, the human is defined in relation to cybernetic systems—computers, biogenetically engineered organisms, ecosystems, expert systems, robots, androids, and cyborgs— all of which evoke those forms of ambivalence reserved for the Other that is the measure of ourselves. The human cyborg is similar but different from all other cyborgs. Through these transformations questions of difference persist. Human identity remains at stake, subject to change, vulnerable to challenge and modification as the very metaphors prompted by the imaginary Others that give it form themselves change. The metaphor that's meant (that's taken as real) becomes the simulation. The simulation displaces any antecedent reality, any aura, any referent to history. Frames collapse. What had been fixed comes unhinged. New identities, ambivalently adopted, prevail.

- pg. 631

- The very concept of a text, whether unique or one of myriad copies, for example, underpins almost all discussion of cultural forms including film, photography, and their analogue in an age of electronic communication, television (where the idea of "flow" becomes an important amendment). But in cybernetic systems, the concept of "text" itself undergoes substantial slippage. Although a textual element can still be isolated, computer-based systems are primarily interactive rather than one-way, open-ended rather than fixed. Dialogue, regulated and disseminated by digital computation, de-emphasizes authorship in favor of "messages-in-circuit"[6] that take fixed but effervescent, continually variable form. The link between message and substrate is loosened: words on a printed page are irradicable; text on a video display terminal (VDT) is readily altered. The text conveys the sense of being addressed to us. The message-in-circuit is both addressed to and addressable by us; the mode is fundamentally interactive, or dialogic. That which is most textual in nature—the fixed, read-only- memory (ROM), and software programs—no longer addresses us. Such texts are machine addressable. They direct those operational procedures that ultimately give the impression that the computer responds personally to us, simulating the processes of conversation or of interaction with another intelligence to effect a desired outcome. Like face-to-face encounter, cybernetic systems offer (and demand) almost immediate response. This is a major part of their hazard in the workplace and their fascination outside it. The temporal flow and once-only quality of face-to-face encounter becomes embedded within a system ready to restore, alter, modify or transform any given moment to us at any time. Cybernetic interactions can become intensely demanding, more so than we might imagine from our experience with texts, even powerfully engaging ones. Reactions must be almost instantaneous, grooved into eye and finger reflexes until they are automatic. This is the bane of the "automated workplace" and the joy of the video game. Experienced video-game players describe their play as an interactive ritual that becomes totally self-absorbing. As David, a lawyer in his mid thirties interviewed by Sherry Turkle, puts it,

- ☐ At the risk of sounding, uh, ridiculous, if you will, it's almost a Zen type of thing. . . . When I can direct myself totally but not feel directed at all. You're totally absorbed and it's all happening there. . . . You either get through this little maze so that the creature doesn't swallow you up or you don't. And if you can focus your attention on that, and if you can really learn what you're supposed to do, then you really are in relationship with the game.[7]
- ☐ The enhanced ability to test the environment, which Benjamin celebrated in film ("The camera director in the studio occupies a place identical with that of the examiner during aptitude tests," p. 246) certainly continues with cybernetic communication.[8] The computer's dialogic mode carries the art of the "what if" even further than the camera eye has done, extending beyond the "what if I could see more than the human eye can see" to "what if I can render palpable those possible transformations of existing states that the individual mind can scarcely contemplate?"
- ☐ If mechanical reproduction centers on the question of reproducibility and renders authenticity and the original problematic, cybernetic simulation renders experience, and the real itself, problematic. Instead of reproducing, and altering, our relation to an original work, cybernetic communication simulates, and alters, our relation to our environment and mind. As Jean Baudrillard argues, "Instead of facilitating communication, it (information, the message- in-circuit) exhausts itself in the *staging* of communication . . . this is the gigantic simulation process with which we are familiar."[9]
- ☐ Instead of a representation of social practices recoded into the conventions and signs of another language or sign- system, like the cinema, we encounter simulacra that represent a new form of social practice in their own right and represent nothing. The photographic image, as Roland Barthes proposed, suggests "having been there" of what it represents, of what is present-in-absentia.
- ☐ The computer simulation suggests only a "being here" and "having come from nowhere" of what it presents, drawing on those genetic- like algorithms that allow it to bring its simulation into existence, *sui generis*. Among other things, computer systems simulate the dialogical and other qualities of life itself.
- ☐ What cannot be represented in language directly (the bodily, living "me" that writes or utters words) can significantly inflect speech, and dialogue, despite its enforced exclsion from any literal representation.

- ☐ pg. 632
  - ☐ In cybernetic systems, though, "I" and "you" are strictly relational propositions attached to no substantive body, no living individuality. In place of human intersubjectivity we discover a systems interface, a boundary between cyborgs that selectively passes information but without introducing questions of consciousness or the unconscious, desire or will, empathy or conscience, saved in simulated forms.
  - ☐ Even exceptions like ELIZA, a program designed to simulate a therapeutic encounter, prove the rule. "I" and "you" function as partners in therapy only as long as the predefined boundaries are observed.
  - ☐ Simulations like these may bring with them the shock of recognizing the reification of a fundamental social process, but they also position us squarely within the realm of communication and exchange cleanly evacuated of the intersubjective complexities of direct encounter. Cybernetic systems give form, external expression, to processes of the mind (through messages-in-circuit) such that the very ground of social cohesion and consciousness becomes mediated through a computational apparatus. Cybernetic interaction achieves with an other (an intelligent apparatus) the simulation of social process itself.
  - ☐ Cybernetic dialogue may offer freedom from many of the apparent risks inherent in direct encounter; it offers the illusion of control. This use of intelligence provides a lure that seems to be much more attractive to men than women.
  - ☐ particularly regarding the question of the look or gaze.
  - ☐ This entire issue becomes circumvented in cybernetic systems that simulate dialogic interaction, or face-to-face encounter, but exclude not only the physical self or its visual representation but

also the cinematic apparatus that may place the representation of sexual difference within a male-dominant hierarchy.

- ☐ Simulated intersubjectivity as a product of automated but intelligent systems invokes its own peculiar psycho-dynamic. Mechanical reproduction issues an invitation to the fetishist—a special relationship to the images of actors or politicians in place of any more direct association. The fetish *object*—the image of the other that takes the place of the other—becomes the center of attention while fetishistic viewers look on from their anonymous and voyeuristic, seeing-but-unseen sanctuary in the audience.
- ☐ But the output of computational systems stresses simulation, interaction, and process itself. Engagement with this *process* becomes the object of fetishization rather than representations whose own status as produced objects has been masked.
- ☐ Cybernetic interaction emphasizes the fetishist rather than the fetish object: instead of a taxonomy of stars we find a galaxy of computer freaks.
- ☐ The consequence of systems without aura, systems that replace direct encounter and realize otherwise inconceivable projections and possibilities, is a fetishism of such systems and processes of control themselves. Fascination resides in the subordination of human volition to the operating constraints of the larger system. We can talk to a system whose responsiveness grants us an awesome feeling of power.But as Paul Edwards observes, "Though individuals . . . certainly make decisions and set goals, as links in the chain of command they are allowed no choices regarding the ultimate purposes and values of the system. Their 'choices' are . . . always the permutations and combinations of a predefined set."[12]

- ⊟ pg. 633
  - ☑ The desire to exercise a sense of control over a complex but predefined logical universe replaces the desire to view the image of another over which the viewer can imagine himself to have a measure of control. The explosive power of the dynamite of the tenth of a second extolled by Benjamin is contained within the channels of a psychopathology that leaves exempt from apperception, or control, the mechanisms that place ultimate control on the side of the cinematic apparatus or cybernetic system.These mechanisms—the relay of gazes between the camera, characters and viewer, the absorption into a simulacrum with complex problems and eloquent solutions—are the ground upon which engagement occurs and are not addressable within the constraints of the system itself. It is here, at this point, that dynamite must be applied.
  - ☐ ..."The equipment-free aspect of reality here (in films) has become the height of artifice; the sight of immediate reality has become an orchid in the land of technology" (p. 233).
  - ☐ With cybernetic systems, this other scene from which complex rule-governed universes actually get produced recedes further from sight. The governing procedures no longer address us in order to elicit a suspension of belief; they address the cybernetic system, the microprocessor of the computer, in order to absorb us into their operation.
  - ☐ The other scene has vanished into logic circuits and memory chips, into "machine language" and interface cards. The chip replaces the copy. Just as the mechanical reproduction of copies revealed the power of industrial capitalism to reorganize and reassemble the world around us, rendering it as commodity art, the automated intelligence of chips reveals the power of postindustrial capitalism to simulate and replace the world around us, rendering not only its exterior realm but also its interior ones of consciousness, intelligence, thought and intersubjectivity as commodity experience.
  - ☐ The chip is pure surface, pure simulation of thought. Its material surface is its meaning without history, without depth, without aura, affect, or feeling. The copy reproduces the world, the chip simulates it. It is the difference between being able to remake the world and being able to efface it. The micro-electronic chip draws us into a realm, a design for living, that fosters a fetishized relationship with the simulation as a new reality all its own based on the capacity to control, within the domain of the simulation, what had once eluded control beyond it. The orchids of immediate reality that Benjamin was wont to admire have become the paper flowers of the cybernetic simulation.
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relationship with the simulation as a new reality all its own based on the capacity to control, within the domain of the simulation, what had once eluded control beyond it. The orchids of immediate reality that Benjamin was wont to admire have become the paper flowers of the cybernetic simulation. the work of art remains susceptible to a double hermeneutic of suspicion and revelation. Mechanical reproduction changes the terms decidedly, but the metonymic or indexical relationship between representational art and the social world to which it refers remains a fundamental consideration.

- ⊟ pg. 634
  - ☐ By contrast, cybernetic simulations offer the possibility of completely replacing any direct connection with the experiential realm beyond their bounds. Like the cinema, this project, too, has its origins in the expansion of nineteenth- century industrialism. The emblematic precursors of the cyborg—the machine as self-regulating system—were those animate, self-regulating systems that offered a source of enchantment even museums could not equal: the zoo and the botanical garden.
  - ☑ At the opening of the first large-scale fair or exhibition, the Great Exhibition of 1851, Queen Victoria spoke of "the greatest day in our history [when] the whole world of nature and art was collected at the call of the queen of cities." Those permanent exhibitions—the zoo and botanical garden— introduced a new form of vicarious experience quite distinct from the aesthetic experience of original art or mechanically reproduced copies. The zoo brings back alive evidence of a world we could not otherwise know, now under apparent control. It offers experience at a remove that is fundamentally different as a result of having been uprooted from its original context. The indifferent, unthreatened, and unthreatening gaze of captive animals provides eloquent testimony to the difference between the zoo and the natural habitat to which it refers. The difference in the significance of what appears to be the same thing, the gaze, indicates that the change in context has introduced a new system of meanings, a new discourse or language.
  - ☐ the zoo and botanical garden exhibit a predefined, self-regulating world with no reality outside of its own boundaries. These worlds may then become the limit of our understanding of those worlds to which they refer but of which we seldom have direct knowledge.
  - ☐ Computer-based systems extend the possibilities inherent in the zoo and garden much further. The ideal simulation would be a perfect replica, now *controlled* by whomever controls the algorithms of simulation—a state imaginatively rendered in films like *The Stepford Wives* or *Blade Runner* and apparently already achieved in relation to certain biogenetically engineered micro-organisms. Who designs and controls these greater systems and for what purpose becomes a question of central importance.
  - ☑ **The Cybernetic Metaphor: Transformations of Self and Reality**
  - ☐ The problems of tracking antiaircraft weapons against extremely fast targets prompted the research and development of intelligent mechanisms capable of predicting future states or positions far faster than the human brain could do. The main priorities were speed, efficiency and reliability; i.e., fast-acting, error-free systems. ENIAC (Electronic Numerical Integrator and Computer), the first high-powered digital computer, was designed to address precisely this problem by performing ballistic computations at enormous speed and allowing the outcome to be translated into adjustments in the firing trajectory of antiaircraft guns.[13]
  - ☐ "The men [*sic*] who assembled to solve problems of this order and who formalized their approach into the research paradigms of information theory and cognitive psychology through the Macy Foundation Conferences, represent a who's who of cybernetics: John von Neumann, Oswald Weblen, Vannevar Bush, Norbert Wiener, Warren McCulloch, Gregory Bateson and Claude Shannon, among others." Such research ushers in the central metaphors of the cybernetic imagination: not only the human as an automated but intelli- gent system, but also automated, intelligent systems as human, not only the simulation of reality but the reality of the simulation.These metaphors take form around the question, the still unanswered question, put by John Stroud at the Sixth Macy Conference:

    > We know as much as possible about how the associated gear bringing the information to the tracker [of an anti-aircraft gun] operates and how all the gear from the tracker to the gun operates. So we have the human operator surrounded on both sides by very precisely known mechanisms and the question comes up, "What kind of machine have we placed in the middle?"[14]

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  - ☐ This question of "the machine in the middle" and the simulation as reality dovetails with Jean Baudrillard's recent suggestion that the staging powers of simulation establish a hyperreality we only half accept but seldom refute: "Hyperreality of communication of meaning: by dint of being more real than the real itself, reality is destroyed."[15]
  - ☐ Such metaphors, then, become more than a discovery of similarity, they ultimately propose an identity. Norbert Wiener's term "cyborg" (cybernetic organism) encapsulates the new identity which, instead of seeing humans reduced to automata, sees simulacra which encompass the human elevated to the organic. Consequently, the human cognitive apparatus (itself a hypothetical construct patterned after the cybernetic model of automated intelligence) is expected to negotiate the world by means of simulation.
  - ☐ Our cognitive apparatus treats the real as though it consisted of those properties exhibited by simulacra. The real becomes simulation. Simulacra, in turn, serve as the mythopoeic impetus for that sense of the real we posit beyond the simulation.
  - ☐ These simulations lack the full-blown, catastrophic consequences of real war, but this does not diminish the reality of this particular simulation nor the force with which it is mapped onto a historical "reality" it simultaneously effaces. Individuals find their lives irreversibly altered, people are wounded, many die. These indelible punctuation marks across the face of the real, however, fall into place according to a discourse empowered to make the metaphoric reality of the simulation a basic fact of existence.
  - ☐ A more complex example of what it means to live not only in the society of the spectacle but also in the society of the simulacrum involves the preservation/simulation of life via artificial life-support systems. In such an environment, the presence of life hinges on the presence of "vital signs." Their manifestation serves as testimony to the otherwise inaccessible presence of life itself, even though life in this state stands in relation to the "immediate reality" of life as the zoo stands in relation to nature. The important issue here is that the power of cybernetic simulations prompts a redefinition of such fundamental terms as life and reality, just as, for Benjamin, mechanical reproduction alters the very conception of art and the standards by which we know it. Casting the issue in terms of whether existence within the limits of an artificial life-support system should be considered "life" obscures the issue in the same way that asking whether film and photography are "art" does. In each case a presumption is made about a fixed, or ontologically given, nature of life or art, rather than recognizing how that very presumption has been radically overturned.
  - ☐ And from preserving life artificially, it is a small step to creating life by the same means. There is, for example, the case of Baby M. Surrogate mothering, as a term, already demonstrates the reality of the simulation: the actual mothering agent—the woman who bears the child— becomes a *surrogate,* thought of, not as a mother, but as an incubator or "rented uterus," as one of the trial's medical "experts" called Mary Beth Whitehead. The *real* surrogate mother, the woman who will assume the role of mother for a child not borne of her own flesh, becomes the real mother, legally and familiarly. The law upholds the priority of the simulation and the power of those who can control this system of surrogacy—measured by class and gender, for it is clearly upper-class males (Judge Harvey Sorkow and the father, William Stem) who mobilized and sanctioned this particular piece of simulation, largely, it would seem, given the alternative of adoption, to preserve a very real, albeit fantastic preoccupation with a patriarchal blood line.
- ☐ pg. 636
  - ☐ Here we have the simulation of a nuclear family—a denucleated, artificial simulation made and sanctioned as real, *bona fide*. The trial evoked the reality of the prototypical bourgeois family: well-educated, socially responsible, emotionally stable, and economically solvent, in contrast to the lower middle-class Whitehead household. The trial judgment renders as legal verdict the same moral lesson that Cecil Hepworth's 1905 film, *Rescued by Rover,* presents as artistic theme: the propriety of the dominant class, the menace of an unprincipled, jealous and possessive lower class, the crucial importance of narrative donors like the faithful Rover and of social agents like the patronizing Sorkow, and the central role of the husband as the patriarch able to preside over the constitution and re-constitution of his family. Now replayed as simulation, the morality play takes on a reality of its own. People suffer, wounds are inflicted. Lives are irreversibly altered, or even created. Baby M is a child conceived as a product to be sold to fill a position within the signifying discourse of patriarchy.
  - ☐ The role of the judge in this case was, of course, crucial to its outcome. His centrality signals the importance of the material, discursive struggles being waged within the realm of the law. Nicos Poulantzas argues that the juridical-political is the dominant or articulating region in ideological struggle today. Law establishes and upholds the conceptual frame in which subjects, "free and

equal" with "rights" and "duties," engage on a playing field made level by legal recourse and due process. These fundamental concepts of *individuals* with the right to enter into and withdraw from relations and obligations to others underpin, he argues, the work of other ideologically important regions in civil society.[16]

- ☐ Whether the juridical-political is truly the fulcrum of ideological contestation or not, it is clearly a central area of conflict and one in which some of the basic changes in our conception of the human/computer, reality/simulation metaphors get fought out. Reconceptualizations of copyright and patent law, brought on by computer chip design, computer software, and biogenetic engineering, give evidence of the process by which a dominant ideology seeks to preserve itself in the face of historical change.
- ☐ Conceptual metaphors take on tangible embodiment through discursive practices and institutional apparatuses. Such practices give a metaphor historical weight and ideological power. Tangible embodiment has always been a conscious goal of the cybernetic imagination where abstract concepts become embedded in the logic and circuitry of a material substrate deployed to achieve specific forms of result such as a computer, an antiaircraft tracking system or an assembly-line robot. These material objects, endowed with automated but intelligent capacities, enter our culture as, among other things, commodities. As a peculiar category of object these cyborgs require clarification of their legal status. What proprietary rights pertain to them? Can they be copyrighted, patented, protected by trade secrets acts; can they themselves as automated but intelligent entities, claim legal rights that had previously been reserved for humans or other living things on a model akin to that which has been applied to animal research?
- ☐ The answers to such questions do not fall from the sky. They are the result of struggle, of a clash of forces, and of the efforts, faltering or eloquent, of those whose task it is to make and adjudicate the law. New categories of objects do not necessarily gain the protection of patent or copyright law. One reason for this is that federal law in the United States (where most of my research on this question took place) and the Constitution both enshrine the right of individuals to private ownership of the means of production while also enjoining against undue forms of monopoly control. The Constitution states, "The Congress shall have power . . . to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." Hence the protection of intellectual property (copyright and trademark registration) or industrial and technological property (patents) carves out a proprietary niche within the broader principle of a "free flow" of ideas and open access to "natural" sources of wealth.

- ⊟ pg. 637
  - ☑
  - ☐ The cybernetic organism, of course, confounds the distinction between intellectual and technological property. Both a computer and a biogenetically designed cell "may be temporarily or permanently programmed to perform many different unrelated tasks."[17] The cybernetic metaphor, of course, allows us to treat the cell and the computer assources of the same problem. As the author of one legal article observed, "A ribosome, like a computer, can carry out any sequence of assembly instructions and can assemble virtually unlimited numbers of different organic compounds, including those essential to life, as well as materials that have not yet been invented."[18] What legal debates have characterized the struggle for proprietary control of these cyborgs?
  - ☐ Regarding patents, only clearly original, unobvious, practical applications of the "laws of nature" are eligible for protection, a principle firmly established in the Telephone Cases of 1888 where the Supreme Court drew a sharp distinction between electricity itself as nonpatentable since it was a "force of nature" and the telephone where electricity was found, "A new, specific condition not found in nature and suited to the transmission of vocal or other sounds."
  - ☐
  - ☐ This finding ran against the grain of the long-standing *White-Smith Music Publishing Co v. Apollo Co* decision of 1908 where the Supreme Court ruled that a player-piano roll was ineligible for the copyright protection accorded to the sheet music it duplicated. The roll was considered part of a machine rather than the expression of an idea. The distinction was formulated according to the code of the visible: a copyrightable text must be visually perceptible to the human eye and must "give to every person *seeing* it the idea created by the original."[19]

- ☐ Copyright had the purpose of providing economic incentive to bring new ideas to the marketplace. Copyright does not protect ideas, processes, procedures, systems or methods, only a specific embodiment of such things. (A book on embroidery could receive copyright but the process of embroidery itself could not.) Similarly, copyright cannot protect useful objects or inventions. If an object has an intrinsically utilitarian function, it cannot receive copyright. Useful objects can be patented, if they are original enough, or protected by trade secrets acts. For example, a fabric design could receive copyright as a specific, concrete rendition of form. It would be an "original work of authorship" fixed in the tangible medium of cloth and the "author" would have the right to display it as an ornamental or artistic object without fear of imitation. But the same fabric design, once embodied in a dress, can no longer be copyrighted since it is now primarily a utilitarian object. Neither the dress, nor any part of it, can receive copyright. Others would be free to imitate its appearance since the basic goal (according to a somewhat non-fashion-conscious law) is to produce a utilitarian object meant to provide protection from the elements and a degree of privacy for the body inside it.

- ☐ pg. 638
  - ☐ What then of a video game? Is this an original work of authorship? Is it utilitarian in essence? And if it is eligible for copyright, what element or aspect of it, exactly, shall receive this copyright?
  - ☐ For video games like *Pac-Man*, a copyright procedure has developed that gives protection to the outward manifestation of the underlying software programs. Registration of a copyright does not involve depositing the algorithms structuring the software of the ROM (read-only memory) chip in which it is stored. Instead, registration requires the deposit of a videotape of the game in the play mode.[20]

    Referring to requirements that copyright is for "original works of authorship fixed in any tangible medium," Federal District Courts have found that creativity directed to the end of presenting a video display constitutes recognizable authorship and "fixation" occurs in the *repetition* of specific aspects of the visual scenes from one playing of a game to the next. But fixing precisely what constitutes repetition when subtle variations are also in play is not a simple matter. For example, in *Atari v. North American Phillips Consumer Electronics Corp* (1981), one District Court denied infringement of Atari's *Pac-Man* by the defendant's *K.C. Munchkin*. The decision rested on a series of particular differences between the games despite overall similarities. In elaboration, the court noted that the Munchkin character, unlike Pac-Man, "initially faces the viewer rather than showing a profile." K.C. Munchkin moves in profile butwhen he stops, "he turns around to face the viewer with another smile." Thus the central character is made to have a personality which the central character in *Pac-Man* does not have. *K.C. Munchkin* has munchers which are "spookier" than the goblins in *Pac-Man*. Their legs are longer and move more dramatically, their eyes are vacant—all features absent from *Pac-Man*.

    This opinion, however, was overturned in *Atari vs North American Phillips* (1982). The Seventh Circuit Court found *Pac-Man*'s expressive distinctiveness to lie in the articulation of a particular kind of pursuit by means of "gobbler" and "ghost-figures," thereby granting broad protection to the game by likening it to a film genre or subgenre. The Circuit Court found the Munchkin's actions of gobbling and disappearing to be "blatantly similar," and went on to cut through to the basic source of the game's appeal and marketability:
  - ☐ Video-games, unlike an artist's painting or even other audio visual works, appeal to an audience that is fairly undiscriminating insofar as their concern about more subtle differences in artistic expression. The main attraction of a game such as Pac-Man lies in the stimulation provided by the intensity of the competition. A person who is entranced by the play of the game, "would be disposed to overlook" many of the minor differences in detail and "regard their aesthetic appeal as the same."[21]
  - ☐ In this decision, the Court stresses the process of absorption and feedback sustained by an automated but intelligent system that can simulate the reality of pursuit. The decision represents quite a remarkable set of observations. The fetishization of the image as object of desire transforms into a fetishization of a process as object of desire. This throws as much emphasis on the mental state of the participant as on the exact visual qualities of the representation ("A person who is entranced by the play of the game").
  - ☐ In these cases the courts have clearly recognized the need to guarantee the exclusive rights of authors and inventors (and of the corporations that employ them) to the fruits of their discoveries. Simultaneously, this recognition has served to legitimate the cybernetic metaphor and to renormalize the political-legal apparatus in relation to the question: who shall have the right to control the cybernetic system of which we are a part? On the whole, the decisions have funneled that control back to a discrete proprietor, making what is potentially disruptive once again consonant with the social formation it threatens to disrupt.
- ⊟ pg. 639
  - ☑ Such decisions may require recasting the legal framework itself and its legitimizing discourse. Paula Samuelson identifies the magnitude of the transformation at work quite tellingly: "It [is]

necessary to reconceptualize copyright and patent in ways that would free the systems from the historical subjects to which they have been applied. It [is] necessary to rethink the legal forms, pare them down to a more essential base, and adjust their rules accordingly. It [is] necessary to reconceive the social bargain they now reflect."[22]

- ☐ If efforts to gain proprietary control of computer chip masks, soft-ware and video games have prompted little radical challenge from the left, the same cannot be said for bacteria and babies, for, that is, the issues of proprietorship that are raised by new forms of artificial life and artificial procreation where the "social bargain" woven into our discursive formations undergoes massive transformation.
- ☐ The hidden agenda of mastery and control, the masculinist bias at work in video games, in Star Wars, in the reality of the simulation (of invasions, raids and wars), in the masculine need for autonomy and control as it corresponds to the logic of a capitalist marketplace becomes dramatically obvious when we look at the artificial reproduction of human life. The human as a metaphorical, automated, but intelligent system becomes quite literal when the human organism is itself a product of planned engineering.
- ☐ Gametes, embryos, and fetuses become, like other forms of engineered intelligence that have gained legal status, babies- to-be, subject now to the rules and procedures of commodity exchange. Human life, like Baby M herself, becomes in every sense a commodity to be contracted for, subject to the proprietary control of those who rent the uterus, or the test tube, where such entities undergo gestation.
- ☐ Such "engineered fetuses" and babies become so much like real human beings that their origin as commodities, bought and sold, may be readily obscured. They become the perfect cyborg. As with other instances in which a metaphor becomes operative and extends across the face of a culture, we have to ask who benefits and who suffers? We have to ask what is at stake and how might struggle and contestation occur? What tools are at our disposal and to what conception of the human do we adhere that can call into question the reification, the commodification, the patterns of mastery, and control that the human as cyborg, the cyborg as human, the simulation of reality, and the reality of the simulation make evident?
- ☐ Like the normalization of the cybernetic metaphor as scientific paradigm or the judicial legitimization of the private ownership of cybernetic systems (even when their substrate happens to be a living organism), the justification for hierarchical control of the cybernetic apparatus takes a rhetorical form because it is, in essence, an ideological argument. Dissent arises largely from those who appear destined to be controlled by the "liberating force" of new cybernetic technologies. But in no arena will the technologies themselves be determining. In each instance of ideological contestation, what we discover is that the ambivalences regarding cybernetic technology require resolution on more fundamental ground: that domain devoted to a social theory of power.

- ☐ pg. 640
  - ☐ **Purpose, System, Power: Transformative Potential versus Conservative Practice**
  - ☐ Liberation from any literal referent beyond the simulation, like liberation from a cultural tradition bound to aura and ritual, brings the actual process of constructing meaning, and social reality, into sharper focus. This liberation also undercuts the Renaissance concept of the individual. "Clear and distinct" people may be a prerequisite for an industrial economy based on the sale of labor power, but mutually dependent cyborgs may be a higher priority for a postindustrial postmodern economy. In an age of cybernetic systems, the very foundation of western culture and the very heart of its metaphysical tradition, the individual, with his or her inherent dilemmas of free will versus determinism, autonomy versus dependence, and so on, may very well be destined to stand as a vestigial trace of concepts and traditions which are no longer pertinent.
  - ☐ The testing Benjamin found possible with mechanical reproduction—the ability to take things apart and reassemble them, using, in film, montage, the "dynamite of the tenth of a second"—extends yet further with cybernetic systems: what had been mere possibilities or probabilities manifest themselves in the simulation. The dynamite of nanoseconds explodes the limits of our own mental landscape. What falls open to apperception is not just the relativism of social order and how, through recombination, liberation from imposed order is possible, but also the set of systemic principles governing order itself, its dependence on messages-in-circuit, regulated at

higher levels to conform to predefined constraints. We discover how, by redefining those constraints, liberation from them is possible. Cybernetic systems and the cyborg as human metaphor refute a heritage that celebrates individual free will and subjectivity.

- ☐ If there is liberating potential in this, it clearly is not in seeing ourselves as cogs in a machine or elements of a vast simulation, but rather in seeing ourselves as part of a larger whole that is self-regulating and capable of long-term survival. At present this larger whole remains dominated by parts that achieve hegemony. But the very apperception of the cybernetic connection, where system governs parts, where the social collectivity of mind governs the autonomous ego of individualism, may also provide the adaptive concepts needed to decenter control and overturn hierarchy.
- ☐ Conscious purpose guides the invention and legitimization of cybernetic systems. For the most part, this purpose has served the logic of capitalism, commodity exchange, control and hierarchy. Desire for short-term gain or immediate results gives priority to the criteria of predictability, reliability, and quantifiability. Ironically, the survival of the system as a whole (the sum total of system plus environment on a global scale) takes a subordinate position to more immediate concerns. We remain largely unconscious of that total system that conscious purpose obscures. Our consciousness of something indicates the presence of a problem in need of solution, and cybernetic systems theory has mainly solved the problem of capitalist systems that exploit and deplete their human and natural environment, rather than conserving both themselves and their environment.
- ☐ Anthony Wilden makes a highly germane observation about the zero-sum game, Monopoly. The goal of the game is to win by controlling the relevant environment, the properties, and the capital they generate. But Monopoly and its intensification of rational, conscious purpose masks a logic in the form of being "merely a game" that is deadly when applied to the open ecosystem. Wilden writes, "We usually fail to see that Monopoly supports the ideology of competition by basing itself on a logical and ecological absurdity. It is assumed that the winning player, having consumed all the resources of all the opponents, can actually survive the end of the game. In fact this is impossible. . . . The Monopoly winner [must] die because in the context of the resources provided by the game, the winner has consumed them all, leaving no environment (no other players) to feed on."[25]
- ☐ "There is the discovery," Gregory Bateson writes in one of his more apocalyptic essays, "that man is only a part of larger systems and that the part can never control the whole."[26] The cybernetic metaphor invites the testing of the purpose and logic of any given system against the goals of the larger ecosystem where the unit of survival is the adaptive organism-in-relation-to-its-environment, not the monadic individual or any other part construing itself as autonomous or "whole."[27] "Transgression does not negate an interdiction; it transcends and completes it." The transgressive and liberating potential which Bataille found in the violation of taboos and prohibitions, and which Benjamin found in the potential of mechanically reproduced works of art, persists in yet another form. The cybernetic metaphor contains the germ of an enhanced future inside a prevailing model that substitutes part for whole, simulation for real, cyborg for human, conscious purpose for the decentered goal-seeking of the totality—system plus environment. The task is not to overthrow the prevailing cybernetic model but to transgress its predefined interdictions and limits, using the dynamite of the apperceptive powers it has itself brought into being.

- ☑ Notes:

- ☐ **Global Summary: (Rough Draft)**
  - ☐ The medium as object changes the aura of what is actually being shown. If the representation of the object has a direct correlation to what exists then the aura of the real object is disconnected with the new object in value. The category of value from the original to the new medium is based on how this medium is positioned in culture. The photograph and its a ability to be placed in different medium has a different category from film and video being changed through the economy in production. This category of distribution can lend both the actor (artist) and affiliates a larger venue that can transcend a physical space. Space is then interconnected through different dimensions that formulate an imaginary space. And existence that is supplants are spheres of senses to a logical mapping of a perceived space. An imagined space that is changed from an atomic scale of categories from atoms to bits, and a state of being static to dynamic chemicals.

The NewMedia Reader - 43 Revolution, Resistance, and the Launch of the Web: The Work of Culture in the Age of Cybernetic Systems (Bill Nichols) pp 625-641 (Original Publication 1988) **Links:**

- ☐ The understanding of film and the act of interrupting reality through the camera effects closeups and montages, this also engages our instincts to identify and to symbolically associate the images presented to a new imaginary of knowledge that both liberates and oppresses the the definition of societal value. Value that is both a regime of redefined ownership by the viewer and also is agreed upon societal connection that can lend to results that are both mechanisms of control and of ownership through the imagination of the viewer. The actor, ruler and viewer are complicit in this imaginative space. The space of chemical measure of reality to the biologically synthetic reality. Memories are now illusory space, holographic in nature that can trigger the biological machine to act (firing the regulatory sensors of the body).
- ☐ The use of computers like the camera are put into a regime of control based on how he democratized factors of unification and shared knowledge can be used and form new tribes of like minded individuals.
- ☐ What is now being measured is the measurement of the state of the cybernetic material. The language of the definition of relationships being substituted from physical to textual. New systems of structure, new language and new habits create new ways of relations in society. The cybernetics analysis of substituting and compressing activities are now being compressed through circuitry and the language of software artificial machines.
- ☐ Power has shifted from the Gaze and image to a fetishistic power of process. Of control and the substitution of the real image to an idealized image of the subjects making. (Example, Celebrity & Politician.)
- ☐ The physical traits of Benjamin's critic of the photograph and film have been aligned with the cybernetic world of the machine. Computational chips, memory and circuitry.
- ☐ The root definitions and research to solve problems and to make machines substitute a human connection between mechanical devices is at the root of all motivations of displacement of the real. Simulated space is seen as submitting the real visible world and is transforming to the mediated augmented world of the computation sense.
- ☐ The argument of how the regime of the cybernetic is simlar to the argument of the photograph in the substitution of art lends us to the acknowledgment that the system of technological regime is defining the terms of reality. The facts are that reality cannot be substituted by a cybernetic simulated space, but can intern be substituted by it depending on how it is adopted by society.
- ☐ Now the physical real examples are being spoken interms of the cybernetic. The real is reduced to the signal that defines consequences. Power in all forms but specifically law has the power to redefine and to change the definitions of the accepted simulated data/ signal that impacts humanity (citizens within the context of a nationalistic border).
- ☐ The conclusion of the article demonstrates that the objective is to use the systemic logic of the cybernetic as a mechanism for change. If the objectives are to detach and to subvert the atomic to the informational, then humanity should question the logic that also imposes systemic logic from the individuals fundamental rights of choice. In the cybernetic logic, it is clear that with the control of a single part of the system does not give an overall control to the larger system. Depending on what mechanisms are being constructed and how they are being used. What is being contested is that the overall systemic nature that transcends the philosophy and that permeates society through cultural recognition and laws are changing the overall awareness of nature. The senses and the human mechanism is being coded and comodified simultaneously to function as a component of capitalism. The pursuit of individuality should be a redefinition of the use of cybernetics as a way of life and more as a tool to engage existence for the material quality of the senses.
- ☐ The conclusion is that with all systems of control, their are winners and losers. The power that functions to control the masses is the same power that pushes the use cases without question to the overall society. Law operates as a set of rules that make society function, but the institutional power and control mechanisms are perpetuated by the people using them. The question is why is power centralized from the top, where all definitions of control come from the people who cede control, from the bottom up?
- ☐

- ☐ **Final Drafts**
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  - ☐
  - ☐

Information Arts: Ch. 1.1 Art and Science as Cultural Acts pp. 2-33 **Links:**

- ☐ _Article Summary:
  - ☐ Information Arts: Intersections of Art, Science, and Technology
  - ☐ Author: Stephen Wilson
  - ☐ Ch. 1.1 Art and Science as Cultural Acts pp. 2-33
  - ☐ Year: 2003
  - ☐ Publisher: MIT Press
- ☐ _Glossary
  - ☐ Major Concepts:
    - ☐ Rationalism vs. Empiricism — plato.stanford.edu
  - ☐ Terms
  - ☐ References:
    - ☐ Influential Artists/Thinkers:
    - ☐ Concepts:
    - ☐ Online Sources:
- ☐ _Outline:
  - ☐ **Introduction:**
    - ☐ What do art and science have to do with each other?
    - ☐ Information Arts takes an unorthodox look at this question, focusing on the revolutionary work of artists and theorists who challenge the separations initiated in the Renaissance. It points toward a possible future in which the arts can reassume their historical role of keeping watch on the cultural frontier and in which the sciences and arts inform each other.
    - ☐ Scientific and technological research should be viewed more broadly than in the past: not only as specialized technical inquiry, but as cultural creativity and commentary, much like art.
    - ☐ Art that explores technological and scientific frontiers is an act of relevance
    - ☐ Like research, it asks questions about the possibilities and implications of technological innovation.
    - ☐ In our culture, scientific and technological information is a critical core of that information.
    - ☐ Here, then, are the questions *Information Arts* is attempting to answer:
      - ☐ What kinds of relationships are possible among art, scientific inquiry, and technological innovation? How might art and research mutually inform each other?

- ☐ How are artists investigating techno-scientific research? How have they chosen to relate to the world of research? How does research further their artistic agendas?
- ☐ How do art historians and cultural theorists understand the interactions between culture and research?
- ☐ How do researchers conceptualize? What agendas motivate their work? What future developments are likely to call for cultural commentary and artistic attention?
- ☐
- ☐

- ☐ **Revisiting the Relationship of Art and Techno-Scientific Research (pg. 5)**
  - ☐ **Historical Separations**
    - ☐ The arts and the sciences are two great engines of culture: sources of creativity, places of aspiration, and markers of aggregate identity.
    - ☐ Before the Renaissance, they were united.
    - ☐ Science was called natural philosophy.
    - ☐ Philosophers were as likely to speculate about art and science as about religion and truth.
    - ☐ Visual and performance arts were integrated into the fabric of rituals and daily life.
    - ☐ In the West, the Renaissance initiated an era of specialization. Science became codified as a segregated set of processes and worldviews.
    - ☐ During the Industrial Revolution, science inspired technology and technology inspired science.
    - ☐ 1960s commentator C. P. Snow developed his influential “Two Cultures” theory[1] that concluded that those in the humanities and arts and those in the sciences had developed sufficiently different languages and worldviews that they did not understand each other.
  - ☐ **The Urgency for Reexamination**
    - ☐ Can art and science/technology remain segregated in the twenty-first century?
    - ☐ *nformation Arts* seeks to revisit the relationship of art to scientific and technological research, exploring the pioneering work of artists with emerging research and the prospects for future mutual influences.
    - ☐ Several cultural forces combine to make a reexamination of the disconnection critical.

- ☐ ***Influence on Life*** Technological and scientific research are spreading their influence into every corner of life, from medicine, communication, and government to domestic life, education, and entertainment.
- ☐ ***Influence on Thought*** Science and technology are changing basic notions about the nature of the universe and the nature of humanity.
- ☐ ***Critical Studies and Cultural Theory*** These disciplines challenge traditional ways of studying culture and question the wisdom of trying to understand the arts, humanities, and sciences in isolation from each other and of segregating "high" and "low" culture.
- ☐ ***Artistic Activity*** The increasing level of artistic activity using computers, the Internet, and other areas of scientific interest suggests the impossibility of understanding the fu- ture of the arts without devoting attention to science and technology.
- ☐ Twenty years ago, when I first started my artistic experiments with computers, it was hard to find similarly involved artists or relevant critical perspectives.
- ☐ …. the most interesting work is likely to derive from a deeper comprehension of the un- derlying scientific and technological principles that have guided the computer's de- velopment, and from participation in the research flow that points to the technological future.
- ☐

- ☐ **Organization of the Book**
  - ☐ *Information Arts* aims to be a resource in the reexamination of the relationship between research and art.
  - ☐ It proposes to accomplish this in several ways.
    - ☐ ***Presentation of Artists*** Artists have begun to engage the concepts, tools, and contexts of scientific and technological research, and their work is provocative and intriguing.
    - ☐ ***Overview of Theory*** Cultural theorists, art historians, and artists have begun to write about many issues in techno- culture that are germane to the discussion of the relationship between art and science/technology.
    - ☐ ***Overview of Research Agendas*** This book explores the possibility of viewing art and research as a unified cultural

enterprise and of understanding researchers' worldviews — their goals, category systems, and visions of the future.

- ☐ ***Methodology*** Creation of this book raised a wide variety of methodological ques- tions: How does one locate exemplary artists and researchers working at the fron- tiers of inquiry? How does one assess the quality of works? How have my own biases affected the choices and analysis?
- ☐ ***Sections of the Book*** ....Sections cover major branches of scientific inquiry, such as biology, physi- cal sciences, and mathematics, and areas of technological foment, such as computers, alternative interfaces, telecommunications, and robotics.
- ☐

- ☐ **The Deficiency of Categorization**
  - ☐ Artists resist categorization. Artworks are typically multilayered, addressing many themes simultaneously. Many artists purposely try to confound preexisting categories. The technology used may not be the most important element.
- ☐ **How Does Research Function in Various Artists' Works?**
  - ☐ The artists in the following chapters integrate techno-scientific research in a variety of ways. For some it is a central focus of their art; for others it is an incidental feature. Even for those for whom the connection is central, a variety of theoretical orientations shape their work.
  - ☐ ***Exploration of New Possibilities*** The artist's work itself functions as research into the new capabilities opened up by a line of inquiry.
  - ☐ ***Exploration of the Cultural Implications of a Line of Research*** The artists use the new capabilities to create work that explores the narratives and conceptual frameworks that underlie the research.
  - ☐ ***Use of the New Unique Capabilities to Explore Themes Not Directly Related to the Research*** The technologies provide a new way to address any number of issues not directly related to the technology…installation used motion detection to explore a variety of emotions…..How long would they stay with a particular emotion before they would need to flee by moving their body?

- ☐ ***Incidental Use of the Technology*** Research provides a wealth of new images and materials. ….Some artists find the new images intriguing or beautiful but are not especially interested in the underlying inquires that led to those outcomes or in their cultural implications.
- ☐
- ☐

- ☐ **What Areas of Technological Art Are Included? Which Are Not?**
- ☐ **What Is Technology? What Is High-tech Art? (pg. 9)**
  - ☐ Every creation system beyond the basic apparatus of the body is a technology. At various points in history, charcoal, paints, sculpting tools and techniques, ceramics, and printmaking apparatus were state-of-the-art technologies. More recently, photography, cinema, electric machines, lights, radio, recording technol- ogy, and video were considered high technology.
  - ☐ Technological art is a moving target.
  - ☐ The artistic gesture to move into an area of emerging technology that is radical in one era can end up being unnoteworthy a few years later.
  - ☐ At the early stages of an emerging technology, the power of artistic work derives in part from the cultural act of claiming it for creative production and cultural commentary.
  - ☐ the early history of computer graphics and animation in some ways mimics the early history of photography and cinema.
  - ☐ *Information Arts* generally focuses on art that addresses research activity emerging in the last seven years.
  - ☐ Because of the accelerated pace of technological innovation, even newer technologies are rapidly passing into the stage of institutionalization. Fields such as computer graphics, computer animation, 3-D modeling, digital video, interactive multimedia, and Web art, which were revolutionary a few years ago, have become part of the mainstream.
  - ☐ *Artistic experimentation is quickly be- ing assimilated. For example, computer graphic visual effects that represented inno- vative artistic exploration a few years ago are now part of the standard Photoshop filters available to the millions who own the software. Computer animations in 3-D and effects that were known only by a few media experimenters are now becom- ing standard features of movies and commercials. Interactive computer events that were of interest only to experimental artists fifteen years ago are now part of fields such as computer-assisted education and games. In one of the most*

remarkably speedy transformations, Web art experiments are devoured by the steamrolling com- mercial and media expansion of the World Wide Web almost as soon as they are invented.

- ☐
- ☐ **The Assimilation of Art into Research and Commercial Production**
  - ☐ The pattern of sequential technological invention, artistic experimentation, and commer- cial assimilation is a fascinating part of the story of how the worlds of art and research relate to each other
  - ☐ Artists pursue product development or are affiliated with a corporate research lab. While others resist these connections and passionately defend their independence.
  - ☐ Where do researchers and artists get their ideas? How do they explore their ideas? How are techno-scientific research and art research different? What happens to the explorations over time? Does mainstream assimilation somehow destroy the validity of the work as art?
- ☐ **Definitions and Theoretical Reflections**
  - ☐ debates over the bound- aries of the terms *art* and *science* regularly engage philosophers and historians of art and science. What is art? What is science? What is technology? What are the similarities and differences among the three? What does it mean to call someone a high-tech artist? What is art that is influenced by science? What is science that is influenced by art?
  - ☐ critical theory has been a provocative source of thought about the interplay of art, media, science, and technology.
  - ☐ in its rush to deconstruct scientific research and technological innovation as the manifestation of metanarratives, critical theory leaves little room for the appearance of genuine innovation or the creation of new possibilities.
- ☐ **What is Science? (pg. 12)**
  - ☐ ...science propose a number of defining elements
  - ☐ This set of core ideas includes the following:
    - ☐ an attempt to understand how and why phenomena occur;
    - ☐ focus on the "natural" world;
    - ☐ a belief in empirical information;
    - ☐ a value placed upon objectivity, which is sought through detailed specifications of the operations that guide observation;

    - ☐ the codification into laws or principles (wherever possible precisely expressed in the language of mathematics);
    - ☐ and the continuous testing and refinement of hypotheses.
  - ☐ The underlying assumptions of the scientific approach are that the natural, observed world is real, nature is essentially orderly, and objectivity can be achieved through self-discipline and the reliance on techniques such as the calibration of instruments, repeat- ability, and multi-observer verification.[3]
  - ☐ This core encompasses variations in emphasis
  - ☐ Critical theorists see science as a modernist delusion.
  - ☐ They see the self-constitution of scientist/observer as a continuation of cultural texts focused on domination and exploitation. They challenge the possibility of objectivity, noting the pervasive influences of gender, social position, national identity, and history. They focus on issues such as the social forces and metanarratives that shape the questions and paradigms used in inquiry; the role of socially constructed frameworks at all stages; and the interaction of the observer and the observed phenomenon.
  - ☐ Many analysts have contributed to the critique of science.
  - ☐ Scientists and technolog- ical innovators, however, believe in the ability to discover universal truths and assert that reform can overcome those places where scientific process falls short of its aspira- tions to universality and objectivity.
  - ☐ As evidence of science's validity, they point to the accomplishments of the scientific worldview in building robust, cross-substantiating theoretical structures, and in predicting and controlling the material and organic world.
  - ☐ Any attempt to cross the disciplinary borders between art and science will confront this disjunction today's incarnation of C. P. Snow's "Two Cultures" theory.
  - ☐ Some of the artists ... have created works that join the critique, creating installations that highlight aspects of science that fail the classical hygienic view. Others implicitly accept the power of the canon, building on the formulations of prior research and using processes of experimentation and theoretical elaboration.
- ☐ **What Is Technology? (pg. 13)**
  - ☐ High-tech artists do not necessarily engage science.

- ☐ An examination of the relationship between technology and science is useful for understanding the range of artistic work related to research.
- ☐ Technology is seen as "knowing how,"
- ☐ while science is seen as "know- ing why."
- ☐ Engineers and technologists are seen as primarily interested in making things or refining processes, not in understanding principles.
- ☐ Melvin Kranzberg and Carroll Pursell believe that this definition is too broad. In *Technology in Western Cultures,* they define it more narrowly, as
- ☐ Contemporary definitions of technology some- times call it applied science—the application of scientific principles to solving problems.
- ☐ since technology predates science, it should be seen broadly, as human attempts to shape the physical world:
- ☐ "[technology] for much of its history had little relation to science, for men could and did make machines and devices without under- standing why they worked or why they turned out like they did."[6]
- ☐ Developers of technology used many techniques in refining their methods, including learning from other practitioners, observing all aspects of their environment, and experi- menting based on instinct, and trial and error. The goal was rarely the development of scientific principles. Certainly, the experiments of many artists in finding appropriate innovations to accomplish their artistic goals could fit this description.
- ☐ With the Industrial Revolution and the refinement of science in the eighteenth century, technology began to draw more on scientific understanding to help solve its problems.
- ☐ In the twentieth century, scientific research became a major source of new technologies, and most manufacturers included scientists in their industrial research labs.
- ☐ Historically, technological research is considered somehow less "pure," and less lofty than science.[7]
- ☐ The origins of these attitudes lie deep in the history of Western culture. Among the Egyptians and the Greeks, fabrication was done by slaves or low artisans, and concern with the material world was considered less important than focus on more essential qualities:

- ☐ *City of God,* St. Augustine noted that technological accomplishments were the exercise of "an acuteness of intelligence of so high an order that it reveals how richly endowed our human nature is," as well as a sign of divine benevolence.[9]
- ☐ With the Enlightenment came a positive attitude toward technological prowess. For example, Francis Bacon proposed that science should serve technological innovation, and suggested that the understanding of nature often becomes clear only when trying to manipulate it technologically:
  - ☐ Bacon proposes a reconstruction of science to produce "a line and race of invention that may in some degree subdue and overcome the necessities and miseries of humanity." . . . Mind must utilize art and hand until nature "is forced out of her natural state and squeezed and molded" because "the nature of things betrays itself more readily under the vexations of art than in its natural freedom.[10]
- ☐ Edwin Layton proposes an interactive model in which science and technol- ogy are seen as "mirror images" of each other, using common methods and drawing on common intellectual heritages; technology does not only exploit the "golden eggs" cre- ated by science.[11]
- ☐ This interactive model of technology probably comes close to describing what is meant when something is called high technology, or high-tech art. High-tech artists, like their counterparts in technology development settings, are engaged with the world of science. They draw on theoretical formulation and research results from scientific inquiry. They use systematic methods of experimentation borrowed from science to advance their agendas. The results can inform further work by technologists and scientists.
- ☐ One way to differentiate between science and technology is by intention.
- ☐ Technology developers usually focus on specific utilitarian goals,
- ☐ while scientists search for something more abstract: knowledge.
- ☐ So what is the best way to describe the research undertaken by the artists described in the following chapters?

- ☐ Many focus on the interface between science and technology.
- ☐ A few concentrate more specifically on more classical "scientific" inquiries.
- ☐ Some act like technologists, seeking utilitarian applications of scientific knowledge and processes to further artistic goals.
- ☐ Others engage the scientific world in more open-ended inquiries analogous to those of scientists.
- ☐ artists' work will return to questions about science and technology.
- ☐ What is the relationship of thinking and doing?
- ☐ What does it mean to view the analysis of mind and society as science?
- ☐ How pure can science be?
- ☐ What can we really know of the physical world, since it is seen through the lens of our conceptual frameworks?

- ☐ **What Is Art? (pg. 16)**
  - ☐ The art presented in this book is best understood within the context of the radical shift in the boundaries of "art" over the last century.
  - ☐ Previously, art was produced in his- torically validated media, presented in a limited set of contexts for a circumscribed set of purposes, such as the search for beauty, religious glorification, or the represen- tation of persons and places.
  - ☐ New technological forms, such as photography and cinema, have already raised questions about art. Artists have added new media, new contexts, and new pur- poses.
  - ☐ It has become difficult to achieve consensus on definitions of art, the nature of the aesthetic experience, the relative place of communication and expression, or criteria of evaluation.
  - ☐ Some of the work could even be viewed as the attempt to revisit unresolved issues from move- ments, such as conceptual art, and art and life interventions.
  - ☐ ...understanding the limits of art is significant. For example, on what basis can the work of researchers and techno-scientific artists be differentiated, or is such a distinction even important?
- ☐ **Similarities and Differences between Science and Art (pg. 18)**

Information Arts: Ch. 1.1 Art and Science as Cultural Acts pp. 2-33 **Links:**

- ☐ How are science and art similar? How are they different? This analysis is useful for understanding the prospects for future relationships.
- ☐ Differences between Art and Science Science

  Art:

  Seeks aesthetic response ; Emotion and intuition ; Idiosyncratic ; Visual or sonic communication ; Evocative ; Values break with tradition

  ---

  Science:

  Seeks knowledge and understanding ; Reason

  Normative ; Narrative text communication ; Explanatory ; Values systematic building on tradition and adherence to standards

  ---

  Similarities between Art and Science

  Both value the careful observation of their environments to gather information through the senses.

  Both value creativity.

  Both propose to introduce change, innovation, or improvement over what exists.

  Both use abstract models to understand the world.

  Both aspire to create works that have universal relevance.
- ☐
- ☐ In "Principles of Research," Albert Einstein stated that the artist and the scientist each substitute a self-created world for the experiential one, with the goal of transcen- dence.[14]
- ☐ In "The Contribution of the Artist to Scientific Visualization," Vibeke Sorensen describes artists as "organizers of large amounts of data"; "people who find unusual relationships between events and images"; and "creative interdisciplinarians."
- ☐ Artists are . . . people who create something completely original and new, something beyond the known boundaries of the information base. By using or inventing new tools, they show new uses and applications that synergize and synthesize fields. Artists push the limits of technologies, bring- ing them to previously unattained goals. Artists as well as scientists work with abstract symbols, representations for various realities and working tools. Even the language used by the two groups is similar. Scientists working with mathematics frequently

describe a particularly good explanation or solution as "elegant" . . . The intellectual bridge of abstraction and aesthetic consideration is fundamental to both groups.[15]

- ☐ Feyerabend notes that scientists must create massive theoretical structures to link observation and the underlying "reality."
- ☐ He further asserts that difficulties arise from the extraordinary faith that science places in theoretical structures and the manipulations derived from them. He questions the wisdom of distrusting the world of real things and actions.[18] Feyerabend concludes that science is in many ways very similar to art, in which researchers build research structures and operations to represent their thoughts:
  - ☐ In a way, individual scientists, scientific movements, tribes, nations function like artists or artisans trying to shape a world from a largely unknown material, Being. . . . Or researchers are artists, who, working on a largely unknown material, Being, build a variety of manifest worlds that they often, but mistakenly, identify with Being itself.[19]
- ☐ How is the artist who explores unusual topological structures different from the mathematician focusing on similar topics?
- ☐ How is the algorist who develops a new algo- rithm for graphic output or a new way to get interesting output out of a plotter different from a technology developer?
- ☐ How is the artist exploring the limits of genetic inheritance by breeding mice to eat computer cables different from a biologist?
- ☐ In parallel fashion, one could ask why couldn't much of the work of scientists, researchers, inventors, and hackers be considered art?

- ☐ **Critical Theory and Problematic Issues in the Integration of Art and Techno-Scientific Research (pg. 20)**
  - ☐ Important themes in critical theory include:
    - ☐ the rejection of the modernist idea of one dominant cultural stream;
    - ☐ the impact of mediated images and representation on ideology and behavior;
    - ☐ the emphasis on deconstructing the language systems and metanarratives that shape culture;
    - ☐ critiques of the narratives of progress;
    - ☐ and challenges to science's claim to universal truth and art's claim to an elevated, privileged, avant-garde vision.

- ☐ I examine issues in the application of these analyses, including their limi- tations, and consider other models for the integration of art and techno-scientific research.[20]
- ☐ Critical theory and cultural studies attempt to link the arts, literature, media studies, politics, sociology, anthropology, philosophy, and technology in an interdisciplinary search for relevant concepts and frameworks with which to understand the current world.
- ☐ The technologies explored by artists are the very ones that some analysts see as key to structuring postmodern, postin- dustrial society.
- ☐ They are essential components in creating the mediated vortex of free- floating significations and the implosion of meaning.
- ☐ They are also crucial in the creation of new cultural niches in which issues such as information flow, control, the body, and war become prominent.

- ☐ **Disjunctions between Scientific Worldviews and Critical Theory (pg. 21)**
  - ☐ In the fields of theoretical and applied sciences, there is an optimism
  - ☐ Scientists believe they can refine theory and make universally valid discoveries, and technologists believe they can create technol- ogies that better human life and transform culture in positive ways.
  - ☐ Do these scientists and technologists live in the same world as the culture analysts? The discordance between the worldviews of culture theoreticians and those who work with new technologies may be essential for understanding the contemporary era in a unified cross-disciplinary way.
  - ☐ Artists who work with emerging technologies face a dilemma: they stand with feet in both worlds. On one side they are invited to help create the new technologies and elaborate new cultural possibilities; on the other, they are asked to stand back and use their knowledge of the technology to critically comment on its underrepresented implications.
- ☐ **The Status of Substantive Things and Organisms**

  in a World Dominated by Image and Media (pg. 23)

Information Arts: Ch. 1.1 Art and Science as Cultural Acts pp. 2-33 **Links:**

  - ☐ In a postindustrial information economy, most people are seen as working with mediated abstractions rather than with real things.
  - ☐ The assessment of the decline of the importance of the material world is a critical issue for the arts and culture at large.
  - ☐ In his article "How Engineers Lose Touch," Eugene Ferguson posits that fatal design flaws in advanced technology such as the *Challenger* are due to "inexperience or hubris or both and reflect an apparent ignorance of . . . the limits of stress in materials and people under chaotic conditions. Successful design still requires expert tacit knowledge and intuitive 'feel' based on experience."[26]
  - ☐ Successful design still requires expert tacit knowledge and intuitive 'feel' based on experience."[26]
  - ☐ Historically, the arts have spanned both the material and the representational—work- ing with images at the same time as they celebrated the substantiality and sensuality of real things, as in sculpture and architecture.
  - ☐ Questions of materiality and corporeality are critical for artists working with new technologies. The imaging, communications, and information technologies they work with are key facilitators of this mediated world. The work they do helps to explore and settle new worlds of representation. Yet, it is not inevitable that new technologies only work with representation. The technologies that manipulate physical things, for example: robotics, nanotechnology, material sciences, alternative energy research, and biotechnology, have been less accessible to artists and the general public. These technolo- gies will be increasingly important and point toward futures when technologically medi- ated material things have increasing importance.
- ☐ **The Difficulties of Locating a Rationale for Action in a Deconstructed Milieu (pg. 25)**
  - ☐ Postmodernism and deconstruction can lead to difficulties for the very people who pro- pound them.
  - ☐ If originality, genius, and avant-garde status are outdated, then what is the role of the intellectual, critic, or artist?
  - ☐ What is the origin and justification of their need to create, and what is the motivation of anyone else to listen?

- ☐ He further states that the validity of a writer's arguments depends on assumptions of truth and value, even though this contradicts their theories.
- ☐ In the postmod- ern world, what does it mean to say that one person has a clearer vision than another?

- ☐ **Artists' Stances in Integrating Research (pg. 25)**
  - ☐ Artists who work with emerging technologies have a variety of stances available to them:
    - ☐ (1) continue a modernist practice of art linked with adjustments for the contemporary era;
    - ☐ (2) develop a unique postmodernist art built around deconstruction at its core;
    - ☐ (3) develop a practice focused on elaborating the possibilities of new technology.
  - ☐ In reality, the work of artists inter- weaves these approaches.
- ☐ **Continuing the Modernist Practice of Art with Modifications for the Contemporary Era (pg. 26)**
  - ☐ Some artists' work with emerging technology is essentially no different from the work of artists who use traditional media.
  - ☐ They see themselves engaged in a specialized aesthetic discourse and nurture their personal sensitivity, creativity, and vision.
  - ☐ They work on concerns and in modes developed for art in the last decades, such as realism, expressionism, abstraction, surrealism, and conceptual work.
  - ☐ In fact, they see themselves as essential to progress in art, and seek to cultivate the unique and "revolutionary" expressive capabilities of their new media and tools. They believe that the art world will ultimately incorporate even unprecedented technologies and approaches, such as image processing, interactivity, algorithmic systems, Internetart, and virtual reality.
  - ☐ This stance has certain limitations.
- ☐ **Deconstruction as Art Practice(pg. 27)**
  - ☐ The theories provide concepts, themes, and methodologies for creating artworks that examine and expose the texts, narratives, and representations that underlie contemporary life. Even more, the work can reflexively examine the processes of representation itself within art.

- ☐ Roland Barthes describes the process in "Change the Object Itself":
- ☐ Science, technology, and their associated cultural contexts are prime candidates for theory-based analysis because they create the mediated sign systems and contexts that shape the contemporary world. They are the tools of power and domination that rely on unexamined narratives of progress, power, representation, and nature.
- ☐ The worlds revolving around digital technologies are seen as ripe for critical analysis because of their assurance of the rationality of their directions and their totalizing preten- sions. In theories described in later chapters, art is seen as a "parasite" or disruptor, standing outside the dominant narratives.

- ☐ **Invention and Elaboration of New Technologies and Their Cultural Possibilities as Art Practice (pg. 28)**
  - ☐ Artists can establish a practice in which they participate in research activity rather than remain distant commentators, even while maintaining reservations about the meaning and future of the scientific explosion. Some analysts see scientific and technological re- search as the central creative core of the present era.
  - ☐ As I have described in previous articles,[34] artists can participate in the cycle of re- search, invention, and development in many ways. They can learn enough to become researchers and inventors themselves. The claim that a unification is now impos- sible because scientific or technological research requires mastery of too much spe- cialized knowledge and access to an elaborate research infrastructure must be critically scrutinized.
  - ☐ *The New Landscape in Art and Science,* Gregory Kepes described the need for artists to work with developing science in a proactive way:

    The images and symbols which can truly domesticate the newly revealed aspects of nature will be developed only if we use all our faculties to the full—assimilating with the scientist's brain, the poet's heart and the painter's eyes. It is an integrated vision that we need; but our awareness and understanding of the world and its realities are divided into the rational—the knowledge frozen in words and quantities—and the emotional—the knowledge vested in sensory image and feeling.[35]

- ☐ This kind of practice demands that artists educate themselves enough to function nonsuperficially in the world of science and technology.
- ☐ Taking advantage of unique traditions of the arts, such as valuing iconoclasm and interdisciplinary perspectives, artists can choose to be a part of the efforts to create these new technologies and fields of knowledge. Furthermore, this artistic stance calls for artist participation in other fields beyond the digital technologies that are focused on in this book, such as new biology, materials science, and space exploration.

- ☐ **Summary: The End of Timelessness? (pg. 30)**
  - ☐ The rapid pace of research is part of developments in the industrial age that clash with the hopes for art's timelessness. In the past, master- pieces were expected to transcend time and space. During this century, that tradition has been eroding with the loss of "aura" in technologically reproducible work, the as- cendance of temporary art forms such as live art and installation, and the power of style and media to rapidly reshape consciousness.
  - ☐ *Information Arts* presents the best of research-inspired art. Many are considered mas- terpieces of the genre. But will they always be? The imaginative reach and innovative vision of some of these artists in mastering an area of research to create eye-opening and thought-provoking works is stunning. But the power of these works may be bounded by their sense of timeliness. After the research world has moved on, they might not seem so significant and moving. Indeed, I know this from painful personal experience, as I see some of my experimental computer artwork of fifteen years ago become quaint and archaic. Curiously, many of these old works can never be experienced again, since the requisite technological infrastructure has disappeared.
  - ☐ These are interesting times for the arts. The linkage of art to emerging research may hasten the redefinition of timelessness. We may need to invent a new meaning for the term *masterpiece*. Think of a masterpiece as a work of art that seizes the cultural moment, or as a work that senses the cultural leap represented by a line of research and uses the magic of the arts to expand what it means and explores what

it might become. After the moment passes, the masterpiece will have served its place in history. Like landmarks in science, such as Gallileo's new vision of the universe, these artworks' timelessness is their audacity, even though the new ground they break may become common ground.

- ☐ **Notes:**

- ☐ Global Summary:
  - ☐ The Chapter by Stephen Wilson is defining terms. Asking fundamental questions about how the merging of Art, Science and Technology will redefine and influence culture.
  - ☐ The chapter was an explanation and the outline of how technology and arts can unify with technology to scrutinize what is either being produced by the medium, how it is represented and what it creates. This relationship can be seen as either perpetuating a past agenda or a creation of a new way to create knowledge.
  - ☐ The characteristics of the mediums that incorporate science can be either technical in nature or focus on the system of knowledge creation privileged by the "why" of knowledge creation.

Information Arts: Ch. 3.1 Physical Science Research Agendas and Theoretical Reflections pp. 202 - 221 **Links:**

- ☐ _Article Summary:
  - ☐ Information Arts: Intersections of Art, Science, and Technology
  - ☐ Author: Stephen Wilson
  - ☐ Ch. 3.1 Physical Science Research Agendas and Theoretical Reflections pp. 202 - 221
  - ☐ Year: 2003
  - ☐ Publisher: MIT Press
- ☐ _Glossary
  - ☐ Major Concepts:
  - ☐ Terms
  - ☐ References:
- ⊟ _Outline:
  - ⊟ **Introduction: Questions about the Biggest and Smallest of Things** (p. 203)
    - ☐ For centuries, science was synonymous with the physical sciences, for example, astronomy, physics, and chemistry. Theorists pondered the essential nature of the universe.
    - ☐ They asked questions with profound philosophical import: How did the universe begin? How will it end? What is the place of the earth in the scheme of things? How did the earth come to look like it does? What is the universe made of ? What are its smallest parts? What makes gold gold? What powers the sun? What is the nature of cause and effect? Can we discover the rules sufficiently to predict (or even control) events? What strategies of observation, experimentation, and analysis can increase our understanding?
    - ☑ There have been eras in which artists were actively involved in scientific and applied research focused on the physical world… and the early-twentieth-century artists who were among the first to grasp the revolutionary implications of theories such as relativity and quantum mechanics.
    - ☐ Currently, the art world seems relatively less interested in the physical world than it once was. Even technologically oriented artists concentrate on image generation and communication technologies that help them explore issues of virtuality and representa- tion rather than scientific and engineering research into the physical world.
    - ☐ the world of science expends enormous international intellectual effort to investigate the physical world—everything from the origins of the universe and the inner workings of atoms to

predicting the weather and understanding earthquakes. Materials scientists invent new kinds of substances with unprecedented characteristics, and nanotechnologists explore the possibility of assembling the world atom by atom.

- this section separates out the physical sciences, every chapter of this book indirectly relates to those disciplines Biological organisms are fundamentally con- structed from the same materials as inorganic objects. The virtual worlds of computers and telecommunications depend on the behavior of the materials that make up electronic chips and the physical rules that govern electromagnetic radiation. Because of the future implications of physical science research, it would be a mistake for the arts to totally ignore these worlds.

- **Survey of Research Fields and Agendas** (p. 204)
  - As a preparation for examining artistic work, this section offers a brief survey of research fields and agendas in the physical sciences.
  - The sections that follow elaborate on a few that have attracted artistic attention, for example, nonlinear systems, nanotechnology, and space science.
  - In physics, the challenges to common notions of space, time, and matter that began in the late nineteenth century continue. Atoms have been split into a menagerie of more elementary particles. Space and time interact in ways unlike what most of us have experienced. Under some circumstances, matter and energy cross over into each other's domains. Anomalies call for attention: the act of observation can affect the phenomenon observed; under some situations time seems reversible; some events seem able to commu- nicate instantaneously, even faster than the speed of light.
  - Scientists continue the quest to unravel the mysteries and explain the anomalies. They search for the grand unification theory that can link atomic level forces and gravity, and for theories that can explain the evolution of the universe.
  - The arts are strangely quiet to all this intellectual activity. In *Art and Physics,* Leonard Schlain presents a convincing history of mutual influences between the arts and the physical sciences. He sees the early twentieth century as an especially rich time for associa- tions. He traces similarities in many of the pioneering

themes of modern art to questions that physics was raising about matter, space, and time.

- ☐ **Nonlinear Systems, Chaos, and Complexity** (p. 207)
  - ☐ The area of nonlinear and chaotic systems is one that is attracting both scientific and artistic attention. These analytical systems promise to give new power to understand and predict phenomena of the natural world that have eluded older methodologies.
  - ☐ The hope was that theories could be continually refined until they would be robust enough to explain all observations. In modern times, the physical sciences achieved amazing results by understanding phenomena such as the movement of planets, the falling of objects in gravity, and chemical reactions. It was easy to project out from these results toward the goal of total predictability.
  - ☐ Although general principles may be understood and statistical probabilities identified, the predictability of local specific phenomena may be impossible, for example, the weather or the specific path taken by flowing water or the behavior of biological and human systems. In the last decades the study of complex, nonlinear dy- namic systems has attracted a great deal of scientific interest.
  - ☐ artists have been inspired by this research approach to create works based on natural phenomena. It seems as though the humility and intricacy of this approach is more in tune with artistic sensibilities than the previous deterministic emphasis. For many, there is the feeling that these theories honor most people's experience of the world more faithfully than the cold abstractions. The colorful and provocative language of the field illustrates some of the artistically attractive features, for example, chaos, strange attractors, catastrophe, the butterfly effect, undecidability, monster functions, dyna- mism, and nonlinearality.
  - ☐ *Nonlinearity*
    - ☐ Simply stated, something is linear if its output is proportional to its input.
    - ☐ . . . [nonlinear] example comes from an ecology of animals that compete for food, but in which there is only a fixed amount of food available each day. As long as the population is small, all the animals get plenty of food. They grow and prosper, they reproduce, and the population grows. But it can only grow so far. Once the population is

beyond a balance with the available food, some animals do not get enough. Eventually they cannot reproduce and the population size decreases. In this ecology then, the population growth is a nonlinear function of the available food. At low populations, the growth is positive; at high populations, the growth is negative. . . .

- ☐ Both linearity and reductionism fail, at least as general principles, for complex systems.
- ☐ In complex systems there are often strong interactions between system parts and these interactions often lead to the emergence of patterns and cooperation. That is, they lead to structures that are the properties of groups of parts, and not of the individual constituents.

- ☐ *Chaos*
  - ☐ "chaos," refers in the world of dynamics to the generation of random, unpredictable behavior from a simple, but nonlinear rule. The rule has no "noise," randomness, or probabilities built in. Instead, through the rule's repeated application the long- term behavior becomes quite complicated. In this sense, the unpredictability "emerges" over time.
  - ☐ . . . There are a number of characteristics one observes in a deterministically chaotic system:
    - ☐ • Long-term behavior is difficult or impossible to predict. . . .
    - ☐ • Sensitive dependence on initial conditions. . . .
    - ☐ • Broadband frequency spectrum: That is, the output from a chaotic system sounds "noisy" to the ear. Many frequencies are excited.
    - ☐ • Exponential amplification of errors. . . .
    - ☐ • Local instability versus global stability.
  - ☐ *Complexity*
    - ☐ . "Complexity," as a label of a scientific interest area, generally refers to the study of large-scale systems with many interacting components.
    - ☐ . Complex systems that are often offered up as exam- ples include financial markets with competing firms, social insects (such as those that form ant colonies and build wasp nests), the human immune system, commodity markets in which agents buy and sell through auctions, and the neural circuits of the brain.
    - ☐ . What makes these systems complex, aside from their raw composition, is that the most interest- ing ones exhibit behavior on scales above the level of the constituent components.[1]

- ☐ **Astronomy, Cosmology, and Space Science** (p. 209)
  - ☐ Astronomy is one of the most fundamental of sciences.

Information Arts: Ch. 3.1 Physical Science Research Agendas and Theoretical Reflections pp. 202 - 221 **Links:**

- ☐ . In the contemporary era, cosmology has reached beyond the local solar system to study the origins of stars and the universe. Exotic entities such as super strings, dark matter, and black holes have been identified. Extraterrestrial intelligence has been searched for. Scientists use new sensors outside of visible light to understand what is there.
- ☐ The National Academy of Sciences prepared a research briefing summarizing the research agenda for cosmology. The report explains the work of cosmology, identifying a set of questions that researchers are seeking to answer:
  - ☐ When did the universe start and how will it end?
  - ☐ What is the dark matter and what is its cosmological role?
  - ☐ How did the large-scale structure of matter form, and how large is it?
  - ☐ What can we learn about physical laws from relics of the Big Bang?
  - ☐ Did the universe undergo inflation at a very early stage?
  - ☐ Do physics and cosmology offer a plausible description of creation?[2]
- ☐ The report lists several benefits of cosmological research, including the stimulation of technological development, and contributions to the physics of matter, intellectual appeal, and ethics. It notes:
  - ☐ Finally, our cosmology—every culture's cosmology—serves as an ethical foundation stone, rarely acknowledged but vital to the long-term survival of our culture. Cosmological knowledge affects religious beliefs, ethical choices, and human behavior, which in turn have important long-term implications for humanity. For example, the notion of Earth as a limitless, indestructible home for humanity is vanishing as we realize that we live on a tiny spaceship of limited resources in a hostile environment. How can our species make the best of that? Cosmological time scales also offer a sobering perspective for viewing human behavior. Nature seems to be offering us millions, perhaps billions, of years of habitation on Earth. How can we increase the chances that humans can survive for a significant fraction of that time? Cosmology can turn humanity's thoughts outward and forward, to chart the backdrop against which the possible futures of our species. . . .
- ☐ Some artists (see chapter 3.4) have begun to work with space science as a way of beginning to approach these questions. For example, they have undertaken to put art into space, created projects that could only be seen from space, imagined other

worlds, and participated in the search for extraterrestial intelligence.

- ⊟ **Epistemology—How Do We Know What We Know?** (p. 211)
  - ☐ In art and cultural discourse, the world of stuff no longer seems as important as it once was.
  - ☐ Cultural theorists have demonstrated the power of cultural narratives, media, and ex- pectation to shape what we think we see, touch, taste, and otherwise sense. Even substantive, concrete givens like the body are shown to be a significant construct of culture, as it is a physical reality. We are seen to be in a postmodern, postindustrial, and postbiological era.
  - ☐ The world of the physical sciences is one place where the worldviews of science and contemporary art appear most at odds.
  - ☑ Scientists and engineers by and large still believe in the reality of an external world and our ability to know and manipulate it. Universal is not a dirty word—some realities apply everywhere in the universe. Certainly, there is deep questioning even in science about the role of cognitive frameworks and the possibility that scientists' views of physical reality are more a result of their socialization and the way they frame their questions and design their experiments than any external world out there (see chapters 1.1 and 7.1).
  - ☐ Also, contemporary science has moved quite far from the historical trust it placed in unaided sense perception.
  - ☐ Starting with developments such as the microscope and tele- scope, increasing reliance is placed on instruments to augment and mediate the senses.
  - ☐ Science now concerns itself extensively with phenomena that can't be seen because they are too large, too small, too fast, too slow, outside the sensitivities of our sense organs, or too distant in time.
  - ☐ Elaborate chains of theorizing, reasoning, instrumentation, and observation are required to deduce the nature of physical reality.
  - ☐ Only the accumulation of evidence, its integration with theory, and its occasional verification through observable events (e.g., the explosion of atomic bombs) convince us that the unseeable stuff is really there.

- ☐ This section, however, concentrates on the implications for the arts of areas of science and technology focused on physical and biological "realities." Exciting research probing those realities is under way, and the re- search promises to alter our basic conceptions of the physical and biological universe.
- ☐ Stimulated by the development of virtual worlds, theorists have developed a renewed interest in the problems of epistemology. Epistemology is the area of philosophy that looks at the processes of how we know and establish truth. The reliance of science on augmented sensors raises questions about reality and also about our processes of coming to know reality. Some artists have found that question fascinating in itself.
- ☐ In his article "Real Science and Virtual Science," Roger Malina, an astrophysicist and editor of the journal *Leonardo,* recounts a story about Galileo's experience with instrumentation:
  - ☐ When Galileo first started using a telescope, the story goes that he crossed the valley to the opposing mountain to touch with his hands the objects and details that he was seeing with his lens. This way he verified that he wasn't being fooled when he saw mountains on the moon for the first time in human history.[3]
- ☐ Malina asks: Is the universe observed by instruments the same universe observed by a human without instruments?
- ☐ Don't the instruments introduce their own ways of know- ing?
- ☐ Astronomers are using a menagerie of spectrum sensors to determine the reality of the universe, for example, radio waves, infrared, visible, and ultraviolet. And, astonish- ingly, the universe looks slightly different in each view. Some features spread across all views and some do not. What's really there? Will the real universe identify itself ?
- ☐
- ☐
- ☐
- ☐

- ☐ **Potentially Important Emergent Technologies** (p. 213)
- ⊟ **Nanotechnology** (p. 213)
  - ☑ In recent years the research world has been highly stimulated by nanotechnology. Im- provements in image acquisition and nanometer (billionths of millimeter) manipulation of materials has lead some theorists to conclude that in the not too distant future we will be able to assemble matter atom by atom.

- ☐ Ralph Merkle, a researcher formerly at Xerox PARC, offers the following colorful introduction:
  - ☐ Manufactured products are made from atoms. The properties of those products depend on how those atoms are arranged. If we rearrange the atoms in coal we can make diamond. If we rearrange the atoms in sand (and add a few other trace elements) we can make computer chips. If we rearrange the atoms in dirt, water, and air we can make potatoes. . . . In the future, nanotechnology will let us take off the boxing gloves. We'll be able to snap together the fundamental building blocks of nature easily, inexpensively, and in almost any arrangement that we desire. This will be essential if we are to continue the revolution in computer hardware beyond about the next decade, and will also let us fabricate an entire new generation of products that are cleaner, stronger, lighter, and more precise.
- ☐ The on-line nanotechnology guide offers this assessment of necessary enabling technologies:
  - ☐ Enabling technologies that could be useful in the development of nanotechnology include research in proximal probes such as STMs (scanning tunneling microscope) and AFMs (atomic force microscope), protein design, and the molecular design of molecules containing large quantities of constituent atoms (especially carbon based), self-assembling molecules and molecule design, mechanosynthetic chemistry, and the continuing development of more powerful computer sys- tems and enhanced chemical modeling packages.[4]
- ☐ positional control (the ability to place atoms exactly where needed) and self-replication technology could both be important in advancing nanotechnology.[5]
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- ☐ **Materials Science** (p. 215)
  - ☐ Materials science is the name given to the set of research interests focused on understand- ing the structure and characteristics of physical materials and on developing techniques to create new kinds of materials.
  - ☐ It consists of an integration of chemistry, physics, and engineering.
  - ☐ Materials science is the infrastructure for the microelectronics revolution in its identification of materials that allow for quicker, denser, and lower power consumption and its aid in inventing new kinds of fabrication processes. Superconducting magnets promise infinite energy. Smart materials link the physical characteristics of materials with digital information systems.

Information Arts: Ch. 3.1 Physical Science Research Agendas and Theoretical Reflections pp. 202 - 221 **Links:**

- ☐ Materials science research is expanding in many directions. Here is a sample of this activity drawn from *Materials Science* magazine and *Scientific American:*
- ☐ . Materials science offers an important link between contemporary research and venerable artistic traditions of working with materials such as sculpture, ceramics, and textiles.
- ☐ The following sections offer a sampling of some specific new materials that call out for artistic experimentation:
- ☐ ***Nitinol (Shape Metal)*** This alloy has the strange property of remembering its shape. After it is deformed, it can be automatically returned to its original form by heating. Design- ers imagine car fenders and eyeglass frames that can be fixed after damage merely by heating.
- ☐ ***Piezoelectric Crystals*** These hybrid ceramics possess the unique characteristic of linking electrical stimulation and physical transformation. When force is applied to these crystals they generate an electrical current and the opposite when they change their shape. The conver- sion of electrical force into motion is much more direct, inexpensive, and efficient thanconventional activators such as electric motors and solenoids. Some see this material as allowing important bridges between the digital information and the physical worlds. This technology has already found its way into many commercial products, such as small speakers and warning buzzers. Other developers who use the conversion of force to electrical current are working on inexpensive sensors that can read touch and pressure. Hobbyist researchers have developed small insectoid robots whose motion is generated entirely by piezo action.
- ☐ ***Electroluminescence*** Some mixtures of phosphor with other minerals will glow when placed in an electrical field. Using this characteristic, developers have created flat lights that efficiently glow with a cool light similar to that produced by lightning bugs. Re- searchers have been working to extend the flexibility and applications of this technology, which could potentially allow painted surfaces to generate light. The technology that was originally developed for the military to be used as aircraft lights because of its flatness has now found its most widespread use in backlights for portable computer screens.

- ⊟ **Rapid Prototyping** (p. 218)

- ☑ Digital technology has exacerbated the distinction by adding even greater ease and flexibility to the imagination and design process. Visionaries have dreamed of new technologies that would link digital designs with actual fabrication, eliminating the time-consuming in- tervening steps by which humans had to translate digital renderings into physical things. Eventually there would be total computer integrated manufacturing (CIM) and architec- ture in which the imaginative digital renderings would be automatically converted into machine controls that would assemble physical objects.
- ☐ This technology uses a variety of means to convert digital renderings of designs into physical things.
- ☐ Stereolithography was one of the first processes developed. Other descriptors include: desktop manufacturing, automated fabrication, toolless manufacturing, free- form fabrication; laser sintering; and deposition modeling. Research labs around the world, including NASA's, are experimenting with different kinds of rapid prototyping systems. Rapid prototyping is culturally significant because it moves into territory that is underexplored, namely, the linkage of the virtual and the physical.
- ☐ Here is one descrip- tion from the IIT Research Institute:
  - ☐ The new rapid prototyping technologies are additive processes. They can be categorized by mate- rial: photopolymer, thermoplastic, and adhesives. Photopolymer systems start with a liquid resin, which is then solidified by discriminating exposure to a specific wavelength of light. Thermoplastic systems begin with a solid material, which is then melted and fuses upon cooling. The adhesive systems use a binder to connect the primary construction material. Rapid prototyping systems are capable of creating parts with small internal cavities and complex geometries. Also, the integra- tion of rapid prototyping and compressive processes has resulted in the quicker generation of patterns from which molds are made.[8]

- ☐ **Global Positioning System (GPS)** (p. 219)
  - ☐ GPS makes use of the ancient surveyor's technique of triangulation.
  - ☐ The United States and Soviet Union each used space exploration technology to put up a ring of location- finding satellites.
  - ☐ Each generates a synchronized signal at precise times. An inexpensive electronic receiver on the earth collects the signals, noting the times of arrival. It can then deduce its precise location by using the differences of arrival times from known

satellite locations. The different times of arrival can be translated into distance because all the signals are synchronized to emit at precise times of origination, and then the precise location of the satellites is known. Using the old high school geometry trick of drawing three circles, a location can be found at the intersection of the three.

- ☐ The technology answers an ancient human wish of knowing one's location, which started with the first explorers: one can know where one is or where other fixed or movable persons or objects are with great ease and precision.
- ☐ The technology was origi- nally developed by the military to track the movements of troops and to guide bombing. "Smart" cruise missiles use GPS technology combined with the image processing of satellite photographs to guide them to specific buildings.
- ☐ Although the basic idea is ancient and simple, the technology requires a sophisticated infrastructure of precision timing and the placement of the satellites. Although the tech- nology is capable of identifying location and altitude to within a few millimeters, the military "dumbs" the timing for the nonmilitary user so that it is accurate only to within approximately six meters.

- ⊟ **Summary: Artist Explorations of Physical Science Research and Concepts** (p. 221)
  - ☐ Chapter 3.2 describes the work of artists interested in atomic-level phenomena and nanotechnology.
  - ☑ Chapter 3.3 documents artists working with observable physical phenomena, dynamic systems, and geology. Chapter
  - ☐ 3.4 reviews the work of artists working with space science.
  - ☐
  - ☐
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- ☐ Global Summary:
  - ☐ The Chapter summarized how the physical sciences are applied to the arts. The current research, methodologies and understanding the strategies to employ in a contemporary work. Stephen Wilson defines each area generally with an emphasis in the unification of Scientific methodologies, research goals and motivations.
  - ☐ The areas of interests are complex systems, computational science, physics, fabrication, virtual reality. Creating an instrument that can predict a design future controlling the overall CAS.