DIGITAL ALCHEMY: MATTER AND METAMORPHOSIS IN CONTEMPORARY DIGITAL ANIMATION AND INTERFACE DESIGN

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The recent proliferation of special effects in Hollywood film has ushered in an era of digital transformation. Among scholars, digital technology is hailed as a revolutionary moment in the history of communication and representation. Nevertheless, media scholars and cultural historians have difficulty finding a language adequate to theorizing digital artifacts because they are not just texts to be deciphered. Rather, digital media artifacts also invite critiques about the status of reality because they resurrect ancient problems of embodiment and transcendence.

In contrast to scholarly approaches to digital technology, computer engineers, interface designers, and special effects producers have invented a robust set of terms and phrases to describe the practice of digital animation. In order to address this disconnect between producers of new media and scholars of new media, I argue that the process of digital animation borrows extensively from a set of preexisting terms describing materiality that were prominent for centuries prior to the scientific revolution. Specifically, digital animators and interface designers make use of the ancient science, art, and technological craft of alchemy. Both alchemy and digital animation share several fundamental elements: both boast the power of being able to transform one material, substance, or thing into a different material, substance, or thing. Both seek to transcend the body and materiality but in the process, find that this elusive goal (realism and gold) is forever receding onto the horizon.

The introduction begins with a literature review of the field of digital media studies. It identifies a gap in the field concerning disparate arguments about new media technology. On the one hand, scholars argue that new technologies like cyberspace and digital technology enable radical new forms of engagement with media on individual, social, and economic levels. At the same time that media scholars assert that our current epoch is marked by a historical rupture, many other researchers claim that new media are increasingly characterized by ancient metaphysical problems like embodiment and transcendence. In subsequent chapters I investigate this disparity.

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1.0 INTRODUCTION
NEW MEDIA SCHOLARSHIP: EVOLUTION OR REVOLUTION?

> *For every image of the past that is not recognized by the present as one of it own concerns threatens to disappear irretrievably.*[1]

Media technologies are often hailed by scholars in terms of their novelty. In fact, "new media technology" designates an area of specialty within the field of communication that includes research on the impact of new technology on global politics, literacy, media policy, identity, film, education, and art. Yet at the same time that scholars identify radical differences in the media of today compared to that of yesterday, many approaches associate new media technology with the disembodied voices of the dead and magical transformation. These scholars make larger claims about the history of storage media, showing that some of the issues surrounding new media are very old indeed.

Contemporary approaches to media technologies fall into roughly four categories. The first group examines the social, political, and economic context in which new media are positioned, how they shape and in turn, are shaped by those contexts. The second group argues that new media technologies reconfigure cultural relations to those technologies in radical new ways and are therefore, historically discontinuous with their forbears. The third group argues for historical continuity between media of the past and present. And the last group examines the metaphysical status of new media technology. These scholars argue that media technology, both past and present, consistently raise philosophical issues concerning reality and representation,

[1] Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illuminations*, ed. Hannah Arendt (New York: Schocken Books, 1955).

embodiment and transcendence. New media forms likewise conjure ancient speculations concerning death, decay, obsolescence, and attempts to artificially extend or augment human life. It is important to note however, that I articulate this topology as a convenient entry point into the scholarly discourse surrounding digital media and there is, in reality, significant overlap between each category within the work of individual authors. For example, when confronting the issue of cyberspace and identity, a scholar may simultaneously adopt a contextual position by focusing on the social and economic conditions of users and a historically discontinuous position by arguing that new media rearticulate identity in radical new ways.

Anne Balsamo, for example, argues that new media are radically contextual in terms of the uses and meanings that we garner from them. In her exploration of the cultural figure of the cyborg she shows that the body itself is inscribed by the mechanisms and media of cultural production. In addition, she argues that due to an increasing collapse between the physical body and technological modifications, notions of identity and subjectivity have undergone a radical break with past understandings of embodiment.[2] Despite the fact that many scholars of new media combine a number of theoretical and methodological positions, it is logically inconsistent for a scholar to identify with the metaphysics camp and argue for radical historical rupture at the same time. However, some research in new media technology maintains an untenable relationship between revolutionary change and historical continuity. While both of these positions are appropriate ways to characterize new media, metaphysical speculations that are inherently at odds with historical rupture arguments usually function as a common ground in scholarship that is otherwise divergent. In short, the consistency with which authors of differing methodological positions identify themes of embodiment and transcendence as key issues in the

[2] Anne Balsamo, *Technologies of the Gendered Body: Reading Cyborg Women* (Durham: Duke University Press, 1999).

study of new media technologies is remarkable enough to merit a closer examination. Whether scholarly, popular, or technical in tone, issues concerning embodiment, transcendence, and death are acknowledged to be central to thinking about media technology across the board. This consistency marks the strand of inquiry that I will take up in this dissertation.

The following will examine these four positions in order to situate this work within a scholarly discourse concerning the historical, social, and cultural implications of new media technologies. I will highlight the arguments made in the various orientations toward new media and offer a critique as a means of staking out my own position as it will unfold in this dissertation. I will end with a statement of the problem with these contemporary approaches and a summary of how this dissertation will address that problem, chapter by chapter.

A cursory inspection of scholarship in media technology reveals that a great deal of work in this area is devoted to the individual, social, political, economic, and even industrial consequences of the Internet, virtual reality, and other forms of new media. Many scholars focus on the impact of new media on global politics and examine the way in which countries like China, Canada, and Brazil integrate new technologies within their social and economics systems, particularly in terms of the issues of distribution and accessibility of technologies across economic and cultural boundaries.[3] Among the most prominent of new media studies, are those that tackle social, political, and economic consequences of digital technology within the United

[3],Jabbar Al-Obaidi, "Communication and the Culture of Democracy: Global Media and Promotion of Democracy in the Middle East," *International Journal of Instructional Media* 30, no. 1 (2003), Lance W. Bennett, "Communicating Global Activism," *Information Communication & Society* 6, no. 2 (2003), Alison A. Carr-Chellman, "China's Future with Distance Education: Rhetoric and Realities," *Information Communication & Society* 3, no. 3 (2000), Matthew David, and Jamieson Kirkhope, "New Digital Technologies: Privacy/Property, Globalization, and Law," *Perspectives on Global Development & Technology* 3, no. 4 (2004), Setareh Ghaffari-Farhangi, "The Era of Global Communication as Perceived by Muslims," *International Journal for Communication Studies* 60, no. 4 (1998), Robert Hassan, "Globalization: Information Technology and Culture within the Space Economy of Late Capitalism," *Information Communication & Society* 2, no. 3 (1999), Christopher R. Hughes, "China and the Globalization of Icts: Implications for International Relations," *New Media & Society* 4, no. 2 (2002), Aphra Kerr, "Revisiting Globalisation through the Movie and Digital Games Industries," *Convergence: The Journal of Research into New Media Technologies* 9, no. 1 (2003), Gholam Khiabany, "Globalization and the Internet: Myths and Realities," *Trends in Communication* 11, no. 2 (2003).

States. For instance, many authors examine the economics and politics of Internet accessibility issues.[4] Domestic investigations of government and economic policies concerning the development and distribution of digital technology frequently focus on who has the economic and cultural resources to make use of new media like the Internet and digital cable. Related to these treatments of policy and access, is of course the problem of free speech and how digital technologies are altering public participation in democracy. Therefore, many scholars of new media are particularly concerned about the impact that digital publishing has on conventional journalistic practices.[5] Still others within the 'social impact' group include those interested in the consequences of new media on education, such as distance learning.[6] Many scholars are interested in examining the ways in which communication technologies like the Internet are reconfiguring traditional understandings of identity.[7] At stake here is the question of whether or not 'cyberspace' exerts a liberating influence on society as it enables new forms of identity

[4] Kirsten Foot, and Steven Schneider, "The Web as an Object of Study," *New Media & Society* 6, no. 1 (2004), Eszter Hargittai, "Internet Access and Use in Context," *New Media & Society* 6, no. 1 (2004), Cecelia Merkel Mehra Bharat, and Ann Peterson Biship, "The Internet for Empowerment of Minority and Marginalized Users," *New Media & Society* 6, no. 6 (2004), Neil Selwyn, "Reconsidering Political and Popular Understandings of the Digital Divide," *New Media & Society* 6, no. 3 (2004), Gillian Youngs, "The Political Economy of Time in the Internet Era: Feminist Perspectives and Challenges," *Information Communication & Society* 4, no. 1 (2001).

[5] Kirsten Foot, and Steven Schneider, "The Web as an Object of Study," *New Media & Society* 6, no. 1 (2004), Eszter Hargittai, "Internet Access and Use in Context," *New Media & Society* 6, no. 1 (2004), Cecelia Merkel Mehra Bharat, and Ann Peterson Biship, "The Internet for Empowerment of Minority and Marginalized Users," *New Media & Society* 6, no. 6 (2004), Neil Selwyn, "Reconsidering Political and Popular Understandings of the Digital Divide," *New Media & Society* 6, no. 3 (2004), Gillian Youngs, "The Political Economy of Time in the Internet Era: Feminist Perspectives and Challenges," *Information Communication & Society* 4, no. 1 (2001).

[6] Chika Anyanwu, "Myth and Realities of New Media Technology," *Television & News Media* 4, no. 4 (2003), Diana Joseph, and Denise C. Nacu, "Designing Interesting Learning Environments When the Medium Isn't Enough," *Convergence: The Journal of Research into New Media Technologies* 9, no. 2 (2003), Scott B. Waltz, "Everything New Is Old Again: Technology and the Mistaken Future," *Bulletin of Science, Technology & Society* 23, no. 5 (2003).

[7] Aaron Ben-Ze'ev, "Flirting on and Offline," *Convergence: The Journal of Research into New Media Technologies* 10, no. 1 (2004), Neil Charness, and Patricia Holly, "The New Media and Older Adults: Usable and Useful?" *American Behavioral Scientist* 48, no. 4 (2004), Jonathan James, and Lillie McCreadie, "Cyberporn, Sexuality, and the Net Apparatus," *Convergence: The Journal of Research into New Media Technologies* 10, no. 1 (2004), Mehra Bharat, "The Internet for Empowerment of Minority and Marginalized Users," Peggy S. Meszaros, "The Wired Family: Living Digitally in the Postinformation Age," *American Behavioral Scientist* 48, no. 4 (2004), Rogers A. Richard, ""Is This a Great Time or What?" Information Technology and Erasure of Difference," *World Communication* 28, no. 4 (1999), Belinda Smaill, "Online Personals and Narratives of Self: Australia's Rsvp," *Convergence: The Journal of Research into New Media Technologies* 10, no. 1 (2004), T.L. Taylor, "Multiple Pleasures," *Convergence: The Journal of Research into New Media Technologies* 9, no. 1 (2003).

construction, or whether it further oppresses and alienates users along familiar and hence, historically continuous lines of race, sexual preference, class, and gender. Robert Markley argues, for instance, that "cyberspace, then, can never separate itself from the politics of representation precisely because it is a projection of the conflicts of class, gender, and race that technology both encodes and seeks to erase."[8] Rather than escaping or transcending the fallen world of human prejudice and inequity, Markley rightly points out that the Internet realizes these same social problems in yet another form. This position is prominent among media scholars who argue that media technologies cannot be disengaged from the social context no matter how much some technologies may promise to lift us out of the turmoil of real life through the power of pure information.

Although widely divergent in their objects of critique as well as their methodology, all of the aforementioned approaches speculate about the impact of communication technology on the human condition. Therefore, I situate these approaches under the general category of contextual media studies since they are less concerned with the production of material artifacts than they are with conditions in which these objects emerge and how, in turn, they actively reshape social conditions for better or for worse.

A good example of a study that examines the contextual forces of economics, politics, and industry is *Digital Capitalism* by Dan Schiller.[9] In a historically discontinuous argumentative vein, Schiller theorizes the harmful economic consequences of the inequitable deployment of the Internet. He is committed to an analysis of media technology in terms of familiar, yet ever more sinister market forces that shape it. He states that:

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[8] Robert Markley, "Introduction: History, Theory and Virtual Reality," in *Virtual Realities and Their Discontents.*, ed. Robert Markley (Baltimore: The Johns Hopkins University Press, 1996).
[9] Dan Schiller, *Digital Capitalism: Networking the Global Market System* (Cambridge, MA: MIT Press, 1999).

> The internet is only a leading element in the hurricane of destructive creativity that has cascaded through global telecommunications. At stake in this unprecedented transition to neoliberal or market-driven telecommunications are nothing less than the production base and the control structure of an emerging digital capitalism.[10]

According to this view, new media technologies provide the means for the oppressive regime to function all the more efficiently. New media differ from former communication techniques in their increased potential to debase and alienate human relations under capitalism. Implicit within this argument is a case for 'newness' (what is different or radical about them) by way of a warning. In other words, new media technologies potentiate slavish dependence as well as unequal relations among humans in society. Whether or not these technological forces effect changes in economic, industrial, or social institutions, the outcome of their public use is likely to further estrange us from democratic ideals, since new media are indelibly inscribed by the old liberal market logic. Scholars in this camp assert that technology cannot solve societal woes.

Arguments like these, by focusing on historical, political, and cultural contexts in which a technology is embedded, usually view media artifacts as byproducts of these social forces.[11] Similarly, Stanley Aronowitz warns that "Technoculture emerges from the ruins of the old mechanical-industrial culture. From the perspective of the industrial worker, whether in the factory or the office, the second phase of automatic production—computerization—is merely a

[10] Ibid., p. 37.
[11] Ben H. Bagdikian, *The New Media Monopoly* (Boston: Beacon Press, 2004), David Brande, "The Business of Cyberpunk: Symbolic Economy and Ideology in William Gibson," in *Virtual Realities and Their Discontents*, ed. Robert Markley (Baltimore: The Johns Hopkins University Press, 1996), Robert W. McChesney, *The Corporate Media and the Threat to Democracy* (New York: Seven Stories Press, 1997), Robert W. McChesney, *The Problem of the Media: U.S. Communication Politics in the Twenty-First Century* (New York: Monthly Review Press, 2004), Robert W. McChesney, *Rich Media, Poor Democracy: Communication Politics in Dubious Times* (Urbana: University of Illinois Press, 1999), Brian Winston, *Media Technology and Society: A History from the Telegraph to the Internet* (London: Routledge, 1998).

wrinkle of disempowerment."[12] Much like Dan Schiller, minus the apocalyptic tone, Aronowitz argues that new technologies only reinforce older systems of oppression, such as the alienation of labor. Another strong claim that relates new technologies to the debasement of human life urges, like Schiller, that the democratic potential of the Internet is quickly swallowed up by the logic of late capitalism. "This relationship, namely, a powerful media apparatus linked tightly to salesmanship, creates a general condition that in time threatens the viability and sustainability of human existence itself."[13]

Each of these critiques reflects the potentially deleterious effects of digital culture on the individual, in addition to the larger political and economic system. Indeed one might speculate on the truth of Michael Heim's proclamation that "postmodern theory, with glib talk of 'cyborgs,' 'software cities' and 'virtual communities,' provokes its opponents by flashing a brand of intellectually sophisticated terror."[14] Heim's critique suggests that discussions of media technology often become unhinged from their context when scholars of the social impact of new media, particularly as concerns large scale infrastructures like the global market, do not take into account the micro-practices of the producers and users on the ground. Kathleen Woodward, for instance, argues in a similar vein that "it is absurd to think of technology as 'out of control' or 'autonomous' because it is in fact thoroughly embedded in social processes" and that "it is preferable to remain as concrete as possible when we think about technology, referring to particular technologies in specific contexts . . . rather than to Technology as a monolithic

[12] Stanley Aronowitz, "Technology and the Future of Work," in *Culture on the Brink: Ideologies of Technology*, ed. Gretchen & Timothy Druckrey Bender (Seattle: Bay Press, 1994), p. 25.
[13] Herbert I. Schiller, "Media, Technology, and the Market: The Interacting Dynamic," in *Culture on the Brink: Ideologies of Technology* (Seattle: Bay Press, 1994), p. 21.
[14] Michael Heim, *Virtual Realism* (Oxford University Press, 1998), p. 39.

demonic or liberating force."[15] Michelle Kendrick also places media technology within the psycho-social fabric of actual users in an attempt to argue against tendencies to view technology as either autonomous or transcending social relations. According to her, "cyberspace, therefore, is a cultural conjunction of fictions, projections, and anxieties that exemplify the ways in which technology intervenes in our subjectivity."[16] Similarly Sandy Stone claims that new technologies, what she refers to as "prosthetic communication," have profound effects on psychological notions of identity construction and body image. She notes that, "As with all powerful discourses, their very existence shapes us. Since in a deep sense they are languages, it's hard to see what they do, because what they do is structure seeing. They act on the systems—social cultural, neurological—by which we make meaning. Their implicit messages change us."[17] Stone's observation that technology's impact on us goes beyond socially constructed notions of identity shows the complex overlap of theories at play in some of the best investigations into the various effects of new media technologies and digital culture. Stone is interested in both the cultural and the material aspects of the technology in question. The "both-and" approach is common in contemporary theories that are sophisticated enough to avoid an overarching telos of either technological progress or full scale technological apocalypse.

I don't wish to deny the importance of contextual approaches to theorizing media technology. Their great virtue is to illuminate the institutional framework in which these technologies are usually unequally distributed and funded. These methods provide a much needed check to technological hubris; the belief that new technologies will redeem humanity by

[15] Kathleen Woodward, "From Virtual Cyborgs to Biological Timebombs: Technocriticism and the Material Body," in *Cultures on the Brink: Ideologies of Technology (Discussions in Contemporary Culture)*, ed. Gretchen Bender and Timothy Druckrey (WA: Bay Press, 1994), p. 49.
[16] Michelle Kendrick, "Cyberspace and the Technological Real," in *Virtual Realities and Their Discontents*, ed. Robert Markley (Baltimore: The Johns Hopkins University Press, 1996), p. 145.
[17] Allucquere Rosanne Stone, "Cyberdammerung at Wellspring Systems," in *Immersed in Technology: Art and Virtual Environments*, ed. Mary Anne Moser & Douglas MacLeod (Cambridge: The MIT Press, 1996), p. 115.

allowing democracy to function better than ever or even more ambitiously, to predict a future in which the ideals of democracy have been realized. My objection is simply that these approaches potentially foreclose other modes of inquiry.

Another category of research into new media deploys a historical trajectory. Cultural historians of media comprise a significant body of literature concerning the role of new media technologies, especially since these individuals are called upon to assess and justify the temporal categories by which media are defined as either 'new' or 'old.' Not surprisingly, those that argue for the revolutionary consequences of new media claim that there is something unique and hence, historically discontinuous about the current media landscape. Although certainly most would not maintain a radical break with the past, nonetheless, these people usually advocate for some type of rupture with former modes of understanding mediation technology. For instance, scholars of technology's role in identity formation may argue that the advent of cyberspace fundamentally changes individual self-understandings, and therefore requires a new theory of subjectivity altogether. For instance, Wolfgang Shirmacher argues that, "Whether or not we accept the fact, we have become homo generator, most visibly in gene technology but equally so in communication technology. A philosophical challenge without precedent lies in discovering and reinforcing those traits already in accord with this new type of being."[18] Shirmacher claims that new media, especially in the sense of our dependence on them, has ushered in an age of techno-being that bears little resemblance to past understandings of identity. Most markedly, we are now able to extend ourselves into space in order to create, simulate, and replicate life and identity.

[18] Wolfgang Shirmacher, "Homo Generator: Media and Postmodern Technology," in *Cultures on the Brink: Ideologies of Technology*, ed. Gretchen Bender & Timothy Druckrey (Seattle: Bay Press, 1994), p. 71.

Others have argued the case of the cyborg before Shirmacher. It figures prominently in the work of two supporters of historical rupture. Both Katherine Hayles and Anne Balsamo argue that the cyborg is a being of radical new identity—since it is partially mechanical and partially organic. Developed by Donna Haraway, the term 'cyborg' signals the development of feminist technoscience with its claims that artificial extensions of the human body refigure cultural understandings of embodiment and identity.[19] The cyborg helps conceptualize issues at the heart of technoculture such as the question of whether or not there is any such thing as an authentic material body when the very limits of the flesh are increasingly redefined through artificial means. Similarly, Balsamo combines a focus on embodiment with cultural practices and contexts that are mapped or inscribed onto the body, rendering it a byproduct of the social relations that determine its shape and meaning. Balsamo argues that the particular historical constellation driven by rapid changes in the media environment constitute a break with the past. "This book describes a contemporary cultural conjuncture in which the body and technology are conjoined in a literal sense, where machines assume organic functions and the body is materially redesigned through the applications of newly developed technologies."[20]

Hayles' work is more difficult to characterize because it overlaps with metaphysical issues like embodiment. Hers is a nuanced reading of the symbiotic relationship between the subject and the virtual world. In trying to stake out a new definition of subjectivity that aligns with the "condition of virtuality" she claims that, "whatever the symbiosis is taken to mean, it seems clear that the virtual subject will in some sense be a cyborg."[21] While Balsamo and Hayles do account for the complex relationship between the human body and cyber or virtual

[19] Donna J. Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991).
[20] Balsamo, *Technologies of the Gendered Body: Reading Cyborg Women*, p. 2-3.
[21] Katherine N. Hayles, "The Condition of Virtuality," in *The Digital Dialectic: New Essays on New Media*, ed. Peter Lunenfeld (The MIT Press, 1999), p. 92.

technologies, they nonetheless contextualize this relationship to the point where it is reduced to a symbolic construction within a field of constantly shifting cultural practices.

Again, the technological medium that affords the critique in the first place is submerged beneath the social, cultural, and political practices of groups and individuals that make use of the technology. Therefore, one problem within the body of new media scholarship is that many of these approaches only examine the cultural context of media technology—its reception by 'the public' and the politics and economics of its design and distribution, thereby rendering issues of material production a mere byproduct of social forces. By material aspects I'm referring to how digital media texts are designed and how those formal elements effect ideologies of representation.

Another gap in the scholarship is that we tend to view new media as radically different from its forbears. If historical continuity is suggested, it rarely goes further back than the nineteenth century, such as in the work of Jonathan Crary. Advocates of historical continuity between media of the past and present also argue that new media technologies are impacting society in unprecedented ways. According to Pierre Levy, "never before have the technological, economic, and social changes around us occurred so rapidly or been so destabilizing. Virtualization itself represents the essence, the cutting edge of the mutation taking place."[22] The forerunner of such thinking is Jonathan Crary, who argues in *Techniques of the Observer* that

> The rapid development in little more than a decade of a vast array of computer graphics techniques is part of a sweeping configuration of relations between an observing subject and modes of representation that effectively nullifies most of the culturally established meanings of the terms observer and representation. The formalization and diffusion of computer-generated imagery heralds a ubiquitous implantation of fabricated visual 'spaces' radically

[22] Pierre Levy, *Becoming Virtual: Reality in the Digital Age*, trans. Robert Bononno (New York: Plenum Trade, 1998), p. 16.

> different from the mimetic capacities of film, photography, and television.[23]

Crary argues that radical changes took place between the nineteenth and twentieth centuries that "grounded the truth of vision in the density and materiality of the body." Crary posits that the machinery of mass culture transformed the human sensorium into a subjective and, therefore, fully privatized space for the consumption of visual texts. Additional scholars in the camp of historical rupture include Baudrillard who argues, rather famously, that new media technologies demand a new theory of representation; third order signification, also known as simulacra. According to Baudrillard, in a digitized media landscape, simulation replaces reality.[24]

One of the leading theories of historical continuity borrows from Marshall McLuhan's insight that the content of new media are in a formal sense, old media.[25] Jay Bolter and Richard Grusin take this as a point of departure to argue that new media, virtual technologies, and digital cinema borrow heavily from film conventions. In fact, they argue that the logic of remediation has governed representation for several hundred years. The process of remediation is one whereby the twin goals of immediacy and hypermediacy demand a reworking of the media forms that precede them. For instance, early interactive video games deployed the logic of books while integrating new features that afforded interactivity because they allowed the user to make choices concerning the plot outcome. Bolter and Grusin formulate a theory of media in which the old and the new are materially instantiated in the formats of new media. They claim that, "what is new about new media come from the particular ways in which old media refashion themselves

[23] Jonathan Crary, *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (Cambridge, MA: The MIT Press, 1999), pp. 10-11.
[24] Jean Baudrillard, *Simulations*, trans. Paul Patton Paul Foss, and Philip Beitchman (New York: Semiotext[e], 1983).
[25] Marshall McLuhan, *Understanding Media: The Extension of Man* (Cambridge, MA: The MIT Press, 1964).

to answer the challenges of new media."[26] While Bolter and Grusin claim that although new emergent media are culturally conditioned, the goal of transparency emerges at the level of design. In other words, designers of new media interfaces seek user immediacy by attempting to erase the overt presence of the interface in order to achieve a "transparent presentation of the real."[27] Unlike some historians of new media, Bolter and Grusin maintain that the logic of representation in new media is continuous with the past. They go back as far as Medieval illuminated manuscripts to demonstrate this, yet their analyses stop short of a robust theory of the nature of representing reality. In other words, they limit their objects of analysis to well-known media objects like books, rather than examining the history of the 'idea' of representation itself. They assert that despite design goals, "the logic of transparent immediacy does not necessarily commit the viewer to an utterly naïve or magical conviction that the representation is the same thing as what it represents."[28] This claim warrants closer examination since it suggests that users of new media are sophisticated purveyors of the logic of representation rather than unwitting dupes of the technological apparatus.

The question remains as to why so many scholars, interface designers, digital animators, and science fiction writers remain committed to the goal of realistic representation in the face of ever more skeptical, savvy, and cynical audiences. Bolter and Grusin highlight one of the leading problems in new media scholarship that I will take up in the next two chapters. Namely, that the technologies of production and design are erased in the final product to the extent that scholars and users alike are quite capable of positing that virtual reality constitutes an independent world where one can manipulate the laws of motion, time, and matter. This quasi-religious attitude

[26]Jay David and Richard Grusin Bolter, *Remediation: Understanding New Media* (Cambridge, MA: The MIT Press, 1999).
[27] Ibid., p. 21.
[28] Ibid., p. 30.

toward virtual reality and cyberspace is a topic of much discussion in the literature. Virtual reality is figured as a transcendent universe in which it will some day be possible to upload the mind and leave the body behind.

For a cultural historian of media, there are several philosophical lenses through which to focus this debate. The first perspective reflects the tendency to view new media as historically continuous since there are design goals that remain consistent from one time period to the next. However, historical continuity does not necessarily entail that the growth of new media forms over time is an evolutionary process since that would suggest that these changes are natural. Nevertheless, while skepticism of the term is warranted on the grounds that technological development is determined by cultural practices, the very demarcation between the natural and artificial strikes to the core of new media theories. The line between the artificial construct and natural phenomena is precisely the unstable terrain on which speculation concerning the nature of reality in the face of the virtual rests. It is important to recognize that the illusion of immediacy is a problem germane to the process of representation itself and not the unique property of digital media. It is therefore possible to assert that historical continuity exists between the media of the past and present without suggesting that this continuity is either evolutionary or universal.

The second position concerning the historical development of new media attempts a radical contextualization by arguing that new media are economically, culturally, and aesthetically unique and therefore, differ sharply from their forbears. While these scholars would not disagree that a degree of continuity exists, they would assert that the manner in which new media forms usher in new social practices is worthy of careful scrutiny. This camp often utilizes cultural critique to explore how particular media formats are used by individuals and social

groups. To a greater or lesser degree, some proponents of radical changes adopt a value-based framework in order to argue for the potential of new media to foster or hinder the ideals of social equality and welfare.

I have labeled the last category in my topology the 'metaphysical' approach. Media scholars within this camp comprise a significant percentage of research into new media forms and practices. In fact, essays and articles that address the metaphysical issues germane to debates surrounding the nature of reality and the body are too numerous to list here.[29] But first I would like to clarify what I mean by "metaphysics." I do not hesitate to use a term as vague and troublesome as this one simply because it is a term used by many media scholars. Whether they use the term disparagingly, or as a catch-all for the problem of media, materiality, embodiment, and transcendence, it is bandied about frequently as a useful means to express the more ineffable aspects of 'cyberspace' and 'virtual reality.' Nell Tenhaff, for example, argues that, "the experience [of virtual reality] is intensified by the sense that this projected space has a metaphysical power, it seems to be or is imputed to be a self-sustaining controlling device beyond authorship, a symbolic apparatus outside of the self with the capability of ordering representation and constructing the perceiving subject."[30] Tenhaff describes the experience of virtual reality as a type of merging with the divine or, at the least, as independent of humanity and culture. Similarly, David Porush notes that the fiction of cyberculture is imbued with this profound sense of religiosity. "The literature of cyberspace, a sheerly technological artifact,

[29] Stef Aupers, "The Revenge of the Machines: On Modernity, Digital Technology and Animism," *Asian Journal of Social Science* 30, no. 2 (2002), David J. Gunkel, "Virtually Transcendent: Cyberculture and the Body," *Journal of Mass Media Ethics* 13, no. 2 (1998), Maria Kambouri, and Gareth Schott, "Moving between the Spectral and Material Plane," *Convergence: The Journal of Research into New Media Technologies* 9, no. 3 (2003), Michel S. Laguerre, "Virtual Time," *Information Communication & Society* 7, no. 2 (2004), Philip Lee, "'Nurslings of Immortality': Being Human or Being Digital?" *Media Development* 48, no. 1 (2001), Robert. W. Lucky, "Digital Immortal," *New Republic* 221, no. 19 (1999).

[30] Nell Tenhaff, "Mysteries of the Bioapparatus," in *Immersed in Technology: Art and Virtual Environments.*, ed. Mary Anne Moser & Douglas MacLeod (Cambridge, MA: The MIT Press, 1996).

almost always envisions VR as giving rise to extrarational experiences and effects, including communication with a metaphysical godhead."[31]

Even when metaphysics are not explicitly mentioned, the same theme of embodiment and reality and its problematic relationship to the virtual emerges again and again in the literature. Questions that are raised concerning the status of the material often fall into two categories. First, is the cultural implication of digital technology amount to a longing to leave the body behind? Or rather, to forge symbiotic relationships between flesh and machine, resulting in the much celebrated cyborg? Several authors discuss digital and virtual technologies in tandem with the wish to transcend the body or, to merge technology and flesh into a cyborg. Yet as Margaret Morse notes, "willing the cyborg into being appears to be the equivalent of wishing the problems of organic life away. Yet, unless the human is erased entirely, food and waste will enter the cyborg condition."[32] The problem of the artificial is always, in dialectical fashion, accompanied by the problem of the real or organic. The two remain symbiotically bound in most thinking about virtual reality. According to Cameron Bailey, "an awareness of the physical, 'real' body is crucial to the disembodied projections of cyberspace. The physical body remains as a referent. Cyberspace wouldn't make much sense without it."[33] Similarly, Tenhaff claims that "a desire to merge psychically into some kind of cyberworld has nevertheless entered the popular imagination. The widespread fascination with virtual reality technologies attests to this, the wish to experience a perceptual event so immediate that it eliminates self who must ascribe meaning

[31]David Porush, "Hacking the Brainstem: Postmodern Metaphysics and Stephenson's *Snow Crash*," in *Virtual Realities and Their Discontents*, ed. Robert Markley (Baltimore: The Johns Hopkins University Press, 1996), p. 108.
[32]Margaret Morse, "What Do Cyborgs Eat? Logic in an Information Society," in *Cultures on the Brink: Ideologies of Technology.*, ed. Gretchen Bender andTimothy Druckrey (Seattle: Bay Press, 1994).
[33]Cameron Bailey, "Virtual Skin: Articulating Race in Cyberspace," in *Immersed in Technology: Art and Virtual Environments*, ed. Mary Anne Moser and Douglas MacLeod (Cambridge, MA: The MIT Press, 1996).

to it."[34] Simply put, an artificially constructed reality that is comprised of pure information seems to hold out a promise of immortality. Presumably, the body decays and dies, while information or pure 'mind' does not. "Cyberspace, beyond its business uses, can invoke a parallel and sometimes a transcendent or spiritual world that revives the dead or the spirits of things in the limbo of the possible."[35]

The problem with theorizing and historicizing new media technologies is that these accounts seem to bypass traditional modes of cultural critique (i.e., textual analysis, social construction, discursive or symbolic modes of analysis) because they invite speculation about the status of materiality and the real, the role of embodied presence and interactivity, and a long standing association with the ancient magic of "action at a distance."[36] According to Markley, "It [cyberspace] is, in part, a by-product of a tradition of metaphysics which, boats against the current, bears us back relentlessly to our past."[37] Ancient issues of mortality and spirit emerge unbidden from the awkward contortions necessary when attempting to theorize virtual reality and hence inevitably, reality itself. The following passage underscores virtual reality's role in mediating the sense of physical 'presence' that it promises.

> Systems of virtual reality transmit more than images; they transmit a quasi-presence. Clones, the visible agents or virtual marionettes that we control by our gestures, can affect and modify other marionettes or visible agents and can even remotely activate 'real' devices and operate in the ordinary world. Some bodily functions, such as the ability to manipulate objects, coupled with real-time sensorimotor activities, can thus operate at a distance."[38]

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[34] Nell Tenhaff, "Mysteries of the Bioapparatus," in *Immersed in Technology: Art and Virtual Environments*, ed. Mary Anne Moser & Douglas MacLeod (The MIT Press, 1996), p. 57.
[35] Margaret Morse, "What Do Cyborgs Eat? Logic in an Information Society," in *Cultures on the Brink: Ideologies of Technology*, ed. Gretchen Bender & Timothy Druckrey (Seattle: Bay Press, 1994), p. 206.
[36] John-Durham Peters, *Speaking into the Air: The History of the Idea of Communication* (Chicago: The University of Chicago Press, 1999).
[37] Robert Markley, "Introduction: History, Theory and Virtual Reality," in *Virtual Realities and Their Discontents*, ed. Robert Markley (Baltimore: The Johns Hopkins University Press, 1996), p. 2.
[38] Levy, *Becoming Virtual: Reality in the Digital Age*, p. 39.

Scholarship in the metaphysics group tends to examine new media technology in tandem with the many characteristics it shares with the magical arts. In addition, issues of embodiment, death, and transcendence are also key concepts for these authors as well. However, in what follows, I will argue that many critiques of new media bypass the inherent materiality of its processes and products because these media artifacts have rapidly outstripped our capacity to theorize them with traditional textual, cultural, or rhetorical methods alone. As Ken Hillis argues "though technologies are social constructions, they are more than only this and we commit a disservice to their understanding in subsuming them under social relations."[39] Although many scholars identify a need to study the material nature of the technologies in question, we seem to lack a theoretically robust set of terms to do so, and therefore, there are crucial gaps in new media research.

Unfortunately, however, standard metaphysics with its lofty promise of accessing 'reality itself' has likewise proven an unsatisfactory mode of analysis as the history of that line of inquiry will show. According to Antony Flew, metaphysics refers to several traditions in philosophical thought, such as "an attempt to characterize existence or reality as a whole . . . or particular parts or aspects thereof. It can also be an attempt to explore the realm of experience; to establish indubitable first principles as a foundation for all other knowledge."[40] In contemporary parlance, metaphysics is inflected with religious connotations that, since stemming from the Greeks, it did not originally possess. Certainly, Christian thinkers like St. Thomas Aquinas have used metaphysical methodology to prove the existence of God. But as the definition points out, metaphysics need not be hinged to a religious tradition. A hesitation to use the term derives from this association with religion as well as the fact that it is considered a philosophical dead end.

[39] Ken Hillis, *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality* (Minneapolis: University of Minnesota Press, 1999), p. xxxvii.
[40] Anthony Flew, *A Dictionary of Philosophy*, 2nd ed. (New York: St. Martin's Press, 1979), pp. 229-230.

But since I am not trying to prove the existence of God, nor am I engaged in establishing primary or universal principles, the term functions well to name the problems of organic reality and artificiality that are so central to new media practices and critiques.

Many discussions of media technology within the metaphysical vein are testimonials to the persistent problem of reality and artificiality, embodiment and transcendence. John Peters claims that "As with all new media, writing opens up a realm of the living dead."[41] The metaphor of ghostly traces pervades his entire book in which he argues that "new media gives new life to old dreams of angelic contact by claiming to burst the bonds of distance and death."[42] He locates the origins of metaphysical speculation about storage media in Plato's *Phaedrus* in order to argue that one-to-one communication does not bring us closer to each others souls than mass mediated communication does. Similarly, Friedrich Kittler claims of storage media, "once memories and dreams, the dead and ghosts, become technically reproducible, readers and writers no longer need the powers of hallucination."[43]

Speculations concerning the potential for virtual reality and cyberspace to offer us a type of transcendence are also common. According to James Brook, "The wish to leave body, time, and place behind in search of electronic emulation of community does not accidentally intensify at a time when the space and time of everyday life have become so uncertain, unpleasant and dangerous for many."[44] Similarly Ben Wooley posits that, "The question such crises [the status of reality] pose is whether this means that attitudes to reality have been undermined by the experience of modernity or whether reality itself, something firm and objective, something

[41] John Durham Peters, *Speaking into the Air: A History of the Idea of Communication* (University of Chicago Press, 1999), p. 49.
[42] Ibid., p. 142.
[43] Friedrich A. Kittler, *Gramophone, Film, Typewriter*, trans. Geoffrey Winthropp-Young and Michael Wutz (Stanford, CA, Stanford University Press, 1999), p. 10.
[44] Brook, James, *Resisting the Virtual Life: The Culture and Politics of Information*, ed. James Brook and Iain A. Boal (San Francisco: City Lights, 1995), p. ix.

underpinning the uncertain world of appearances, has been shown to be an illusion. Is the lesson we should have learned from the last century that there is no reality?"[45] Similarly, Ken Hillis argues "as a technology and a social practice, VR exemplifies a Western yearning for transcendence via achieving a physical and cultural imaginative remove of the subject's mind from her or his body. A culture that increasingly accepts the mediate imprint of technical rationality also convinces itself that its peoples' various bodies are almost entirely the product of social relations and thereby only texts."[46] Hillis' quote articulates the irony that only in a culture permeated by 'technical rationalism' is it possible to theorize that bodies are socially constructed texts rather than material things. However, this logic also obtains in the reverse, as shown by John Peters, who instead argues that only during an epoch of increasingly abstract and etherealized media such as cyber communication do bodies begin to matter even more deeply.

Other scholars have noted the persistence of material and metaphysical issues at the heart of investigations into the cultural status of new media technologies. For instance, Jeffrey Sconce claims in *Haunted Media* that "in the end we are always left with a material machine at the heart of such supernatural speculation, a device mechanically assembled, socially deployed, and culturally received within a specific historical moment."[47] Similarly, Don Ihde states that

> Virtually all human activities implicate material culture, and this in turn forms the context for our larger perceptions. Take, as an extreme case, the phenomenon of death. . . . By looking at technologies in this initially broadest sense, we can note that, in contrast to the non-technological Garden, human activity from immemorial time and across the diversity of cultures has always been technologically embedded.[48]

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[45] Benjamin Wooely, *Virtual Worlds: A Journey in Hype and Hyperreality.* (Cambridge: Blackwell Publishers, 1992).
[46] Hillis, *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality*, p. x1.
[47] Jeffrey Sconce, *Haunted Media: Electronic Presence from Telegraphy to Television* (Durham: Duke University Press, 2000), p. 20.
[48] Don Ihde, *Technology and the Lifeworld: From Garden to Earth* (Bloomington: Indiana University Press, 1990), p. 20.

These scholars note that an irreducible material dimension haunts critiques based on socioeconomic, discursive, and historical analysis. In other words, while the artifacts of technological processes are certainly texts to be deciphered, they are also things that exert influence on other things. For instance, computer and software design is based on considerations of ergonomics. Something as seemingly simple as the computer screen has been altered over time to ensure that people don't go blind after staring at it all day and new techniques are explored to make typing more comfortable and to prevent carpal tunnel syndrome. When we talk about media technologies, we are not solely within the realm of ideas, but are attempting to speculate on the cultural role of things.

In a variety of ways, often combining textual and artifact analysis with an examination of social and historical contexts, we find two incongruous positions emerging from these investigations into new media technologies. One strand identifies digital technology as catalyzing a radical shift in both the products and processes of communication and mediation. This shift might be objective—in terms of how efficiently (or oppressively) capital circles the globe—or new media may signal more subjective changes in how we understand, transmit, and perceive information and images. At the same time, another pervasive theme in new media scholarship is the surprisingly ubiquitous observation that all recording media store ghostly traces of human beings and as such, instantiate notions of death, decay, and obsolescence. On the other hand, this mystical position is often reproached on the grounds that it furthers a western prerogative of dominance and promotes delusional dreams of transcending the body and creating more democratic spaces for building cyber communities.[49] Scholars are quick to point out that such positions should be approached with skepticism since they are not only technologically

[49] See Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and Machine* (New York: John Wiley & Sons, Inc., 1948) for early discussions of how technology can redeem humanity. For a fictitious account of the same cultural longings see William Gibson's, *Neuromancer.*

deterministic, but tend to repeat hopeful narratives of older technologies like television, that likewise failed to live up to their utopic potential. Wisely, these scholars point out that cyberspace does not spell the end for the human body, the capitalist economy, nor even for the book. But some scholars may be creating a straw man since rarely are fictional, scientific, and philosophical approaches to digital technology so patently unexamined as to argue for the plausibility of such technology-determined futures worlds. For instance, some of the cyber cult novels and films evoked far more nuanced approaches that invite rich interpretations of the complex relationship between humans and computers. Scholarship of media technology is sometimes in danger of creating a false enemy that it proceeds to pull down with alacrity. I am interested in the construction of this enemy because both the celebration and debasement of technology instantiates the metaphysical problem at the heart of the controversy.

In what follows, I will explicate the methodological and theoretical design of this dissertation. I will first clarify what I mean by the "metaphysics" and transcendence in terms of its relevance to the alchemical and digital objects I will explore in later chapters. I will then lay out the structure of the dissertation: the first argumentative vein is that of historical continuity, and the second is an attempt to define digital representation as cultural artifacts or objects that instantiate historical and social forces in material form.

Alchemy as a cultural practice, demonstrates the metaphysical logic of diminishing horizons. In short, despite breathtakingly real visual effects in contemporary digital practice, the real goal or 'gold' continually slips further away the closer the practitioner comes to realizing the much coveted levels of realism. The operant theory of metaphysics at work in this dissertation is borrowed from Aristotle's theory of the twofold nature of reality. The alchemists were deeply influenced by this theory and attempted to put these concepts into practice. Although certainly

Pre-Socratic thinkers were invested in understanding the material world, few would disagree that Aristotle posits the first systematic approach to natural philosophy. The cultural history of transformation that continues to inform contemporary practices of material transformation can be traced to the long-held belief, stemming from Aristotle, that metamorphosis is possible due to the dual nature of material things. This theory of materiality suggested that objects composed of form and matter can be artificially altered and manipulated. My concern here is not to connect Aristotelian formalism to digital alchemy on the grounds that its understanding of matter is "scientific" but to explicate how these views serve as a cultural substratum of how we think about the status of matter across a wide range of social contexts.

Aristotle helps us understand the thrall of digital special effects, particularly the technique of metamorphosis, by unpacking for us the relationship between material bodies and the forms impressed on them. Aristotle's theory of the relationship between form and matter is outlined primarily in Book VII of *The Metaphysics*.[50] For Aristotle, substance is the answer to the question of *what* a thing is, rather than what *kind* of thing it is. "We must pay attention to the manner of a thing's formula, i.e., of what it is to be that thing . . . for the formula of none of them are independent of change but always include matter."[51] One of the most important insights that we get from Aristotle, and one that has had an influence on his predecessors is that, although form is primary to matter, form can only manifest itself materially. According to Aristotle, form more or less hovers around in the ether as "potential." Therefore, Aristotle identifies a third component that is both 'real' (composed of matter) and unreal (pure potentiality of form). Aristotle calls the composite of form and matter a primary substance. The composite provides a theory of real objects in the world that, unlike Plato's Ideal Forms, do not bypass the material

[50] Aristotle, *A New Aristotle Reader,* Ed. By J.L. Ackrill, New Jersey: Princeton UP, 1987.
[51] Ibid., 1025b 29-1026a 3.

nature of these objects in order to posit a transcendent, and thereby necessarily static, theory of form. This triad, comprised of matter, spirit, and a third component that mediates between that two is neatly applied to many different theoretical systems—mind, body, and spirit; sign, signifier, and signified.

The dynamic existing between this three-part relationship is what enables transformation. The insight we gain from Aristotle's formulation is that processes that involve mediation are dynamic and not static forms of representation. This theory of representation is much more suitable for theorizing digital design than it is for painting, since digital design entails a relationship between the human designer or operator, the object of their actions, and the medium that negotiates the process of design. While analogical forms of art and representation are still legitimate forms of media, they cannot be altered. In fact, permanence is implied in their design (you're not supposed to write in books or alter famous paintings).

As Aristotle found, one cannot discuss matter without including time, specifically the way material things are prone to change. This is clearly what digital designers are up to when they seek to create intelligent tools that mirror the dynamic transformations that occur in nature. Aristotle's theory of the composite of matter and form in turn, proves crucial to a theory of temporal transformation because it attempts to account for the laws that undergird the process of change. The twofold notion of time contained in primary substance gets us a theory of how it is that, during the process of transformation some things change and some do not. As pure potentiality, primary substance, unlike matter, is indestructible. "Since substance is of two kinds, the concrete thing and the formula (I mean that one kind of substance is the formula taken with the matter, while another kind is the formula in its generality), substances in the former sense are capable of destruction (for they are capable also of generation), but there is no destruction of the

formula in the sense that it is ever in the course of being destroyed."[52] Form is eternally coming to be and passing away. It is always in a state of flux. As such, it is the immovable center around which the destructible substance (that which dies) revolves. Therefore, primary substance accounts for the twofold aspects of time in which all "sub-lunar" things are enmeshed; the eternal time of the form and the finite time of matter. "Now there are several senses in which a thing is said to be primary; but substance is primary in every sense—in formula, in order of knowledge, in time. For of the other categories none can exist independently, but only substance. And in formula also this is primary; for in the formula of each term the formula of its substance must be present."[53] From this two-fold nature of substance derives the notion that form is the primary and, as such, the indestructible part of a substance while the material aspect of the substance is subject to change, corruption, and decay. Therefore, the transformation of one thing into another implies an interdependence between the telos of potential form and the actuality of the material manifestation. Both the alchemists and contemporary digital designers realize that accessing natural rhythms requires an aptitude for manipulating the relationship between form and substance. Digital technology is yet one more technique in the history of technologies of manipulation.

In the Aristotelian tradition, if one wants to alter matter, one must learn to tweak the unalterable form of things; the physical laws governed by the four elements that, in a variety of proportional admixtures inform the shape of material reality. The true object of material manipulation is not really matter but form. Since form always exists as potential, it is presumably more malleable than recalcitrant matter. The following will elaborate Aristotle's theory of material transformation by explicating two key philosophical points; first, the definition of

[52] Ibid., 1039b 20-24.
[53] Ibid., 1028a 30-35.

substance as a composite of matter and form and second, the primacy of form as the indestructible aspect of substance. From these key points, it is possible to theorize that anything can be turned into anything else. I argue that Aristotle's theory of material nature found practical expression for alchemists, and continues to exert an influence on the culture and technologies of transformation today.

But what is a primary substance for Aristotle? A primary substance is comprised of some proportional combination of the four elements: earth, air, fire, water, and their properties: hot, cold, moist, and dry. "It is in fact clear that all are by nature able to change into each other . . . So in general it is clear that it is natural for every one to come to be from every other."[54] Because each element shares a property in common with its contrary element, then theoretically any entity can change into any other entity. However, far from being a theory of transcendence, Aristotle's understanding of primary substance, though ethereal because it is indestructible, is nonetheless firmly grounded in the world of flux, which is the world of nature. In other words, although form is eternal, it nevertheless enjoys no existence apart from its material manifestation. Ironically, that which is disembodied turns out to be the most fundamental in the sense that this disembodied ghost of primary substance is only recognizable when it becomes some 'thing.'

I argue that the residual effects of digital alchemy, the attempt to copy nature accurately which inevitably results in an imperfect copy, produces a ghost of this primary form and is therefore, the source of much speculation concerning the role of technology in producing a sense of the uncanny, of death and decay. This phenomenon is not purely social, in the sense that the process produces a residue, nor is it purely philosophical, in terms of a theory of matter and form. Rather, artifacts of digital design and most certainly alchemical manipulation preserve and

[54] Aristotle. "On Generation and Corruption." In *A New Aristotle Reader,* "Book II," 331a 13-21.

resurrect both content and context in that cultural production evokes both empirical and ideal states. These ancient speculations remind us why people have always believed in things that cannot be seen, whether this attitude is magical or its close cousin, scientific. To conjure these invisible realities requires the imperfect technological extensions of enfeebled humans.

Another philosopher that has had a lasting impression on cultural attitudes toward materiality is Plato. Plato's theory of material nature differs markedly from Aristotle due to the questions of value that Plato introduces into the equation. Plato submerges matter and body beneath mind and spirit. In doing so, he introduces a structural and ethical dichotomy that would continue to influence attitudes toward material nature for centuries. Plato's well known theory of ideal forms, illuminated metaphorically in the myth of the charioteer in *The Phaedrus,* views the flesh and material nature as fallen versions of a divine model that are dangerously seductive and detract attention away from higher pursuits. Like most good parables, Plato's myth of the soul is adaptable to a variety of different binary relationships. Critics have discussed *The Phaedrus* work in terms of rhetoric and philosophy, myth and science, erotic love versus chaste love, etc. Most admirably, John Durham Peters has offered a unique read of the text that situates it among the early history of enduring communication models. He, too, demonstrates that Plato's parables are responsible for initiating a particular historical and cultural belief in the metaphysics of presence. One of Peters' central claims is that physical closeness has become the ideal model of communication.[55]

I am clearly not the first to plumb this text as a point of origin for contemporary ideas. In *The Phaedrus*, the myth of the charioteer is the story of the soul's journey toward the divine. The black horse represents the base needs of the body as it strains forward to behold the beloved object, propelled by passion and the promise of pleasure. Reason, the soul's pilot, attempts to

[55] Peters, *Speaking into the Air: The History of the Idea of Communication*.

bring the black horse in line with the obedient white horse. Curiously, however, the more vehemently the charioteer whips the black horse, the more his power seems to increase. This seems to demonstrate the futility of seeking the divine while trapped in the sullied and hungry flesh. The question of attainment of divinity is therefore deferred.

The dichotomy of the black and white horses in Plato's third speech to Lysias suggests that the soul is possessed by an entrenched duality with the flesh that is inescapable. The presence of the white horse suggests transcendence, but the black horse is forever dragging its partner back toward the earth. Why not maintain equality between the two horses as Aristotle would have done? In other words, the team could be described in terms of codependent and equally necessary forces of sympathy and antimony that provide the energy to ignite transformations in the human soul. But as numerous scholars of Plato have pointed out, there is an overarching moral component to this speech in particular, and to his philosophical system in general. The white horse "holds the nobler position and is upright and clean-limbed; it carries its head high, its nose is aquiline, its color white, its eyes dark; it is the lover of honor only when that may be joined with temperance and decency: in other words the follower of true reknown; it needs no whip, but is driven by word of command alone."[56] The black horse on the other hand, "is huge, but crooked, a great jumble of a creature, with a short thick neck, a flat nose, dark color, gray bloodshot eyes, the mate of insolence and knavery, shaggy eared and deaf, hardly heeding whip or spur."[57] In the end, through violent application of whip and bit, the black horse is forced to submit to reason. But this state is a temporary one since, through the froth and bloodshed, the black horse's fury lies dormant. He will always pose a threat. Plato spends a lot more time talking about the black horse. Certainly, it suggests that the relationship between

[56]Plato, "Phaedrus," in *The Collected Dialogues of Plato*, ed. Edith Hamilton and Huntington Cairns (Princeton University Press, 1999), p. 38.
[57] Ibid., p. 38.

bodily desire and spiritual goals is an intensely violent one. Plato includes vivid and sensuous descriptions of the whipped horses' frenzied rebellion. Ironically, this Dionysian orgy of passion brings to the surface the very impulses that the charioteer (and Plato) seek to repress. The doomed attempt to bring the black horse to reign succeeds in drawing forth its most feared aspects instead. Plato cannot eradicate material nature, its unruly impulses, its baseness, mortality, and hunger. In trying to transcend the body, the charioteer remains more firmly bound to his dependency on it. This is consistent with Plato's philosophy which tends to posit that the body is a prison that distorts the Truth and functions as an obstacle to the divine. The mind is "disfigured by this so-called body that we carry about us, imprisoned in it like oysters in a shell."[58] These moral echoes would reverberate for centuries into Christian theology.

The goal of transcendence in Plato is also constantly deferred. Further, I provide an analysis of both of these philosophers because the influence of Aristotle's theory of matter requires exploration since its influence on contemporary scholarship and materiality is commonly suppressed by Platonic theories of ideal form. For example, within current media and communication scholarship, studies of materiality commonly avoid the actual practices and artifacts of new media, opting instead for more contextual means of understanding the impact of new media on society. One reason for this is a persistent tendency to view objects with suspicion as 'fallen.' This attitude stems from Plato, Marx, and Freud who, albeit in very different ways, elaborate an ideological theory of matter whereby what can be seen and touched is dangerously misleading. As I have shown, Plato establishes a hierarchy between matter and form that does not exist in Aristotle's theory, by warning against the pitfalls of believing in what can be seen, or what is manifest in the fallen world. This attitude is still pervasive in communication, cultural, and historical studies today. For instance, one project on the rhetoric of memorial sites claims to

[58] Ibid., p. 34.

understand rhetoric's materiality ends up arguing ideological effects on audience rather than attempting to grasp the material nature of the memorial itself.[59] This problem is common in the field, and understandable. As I have argued earlier in this project, short of lapsing into discredited metaphysical terms, we lack a language to discuss the importance of material things and bodies in communication practices. Aristotle's theory, however, explains why it is that when we attempt to access materiality, we actually end up talking about essence. The two are inextricably wedded. Indeed, Aristotle's primary objection to Platonic forms was that it denied the manifest aspects of objects in the world since these were relegated to a second-class citizenship in relation to the Ideal. The Aristotelian theory, in contrast, takes form as a composite of primary substance and matter. This theory has yet to be excavated for its relevance to the transformative work of contemporary cultural artifacts.

I draw a historical and cultural link between the remote, yet culturally viable, practice of alchemical transmutation and contemporary digital design. Walter Benjamin offers a robust theory of historical continuity with remote epochs through the explanatory metaphor of archaeology. The past lives in the present in the form of a fossil. Similarly, I assert using Walter Benjamin's theory of historical dialectic, that ancient problems reemerge in contemporary digital design in ways that certainly differ from the past. But the material manifestation of a cultural artifact, according to Benjamin, is less important than the logic of fashion that informs it. "Fashion has a flair for the topical, no matter where it stirs in the thickets of long ago; it is a

[59] Carole Blair, "Contemporary U.S. Memorial Sites as Exemplars of Rhetoric's Materiality," in *Rhetorical Bodies*, ed. Sharon Crowley and Jack Selzer (Madison, WI: University of Wisconsin Press, 1999), Anne Demo and K. Deluca, "Imagining Nature and Erasing Class and Race--Carleton Watkins, John Muir, and the Construction of Wilderness," *Environmental History* 6, no. 4 (2001), Janice Hocker Rushing, and Thomas Frentz, "Mother Isn't Quite Herself Today: Myth and Spectacle in the Matrix," *Critical Studies in Mass Communication* 19, no. 1 (2002). Each of these articles' ostensible interest in material practices and artifacts (memorial sites, turn of the century photographs, and digital special effects, respectively) is bypassed by an overarching moral critique of the social conditions that shape them.

tiger's leap into the past."[60] Therefore, contemporary technological artifacts can be simultaneously new and old. According to Benjamin,

> A historical materialist approaches a historical subject only where he encounters it as a monad. In this structure he recognizes the sign of Messianic cessation of happening, or, put differently, a revolutionary chance in the fight for the oppressed past. He takes cognizance of it in order to blast a specific era out of the homogenous course of history—blasting a specific life out of the era or a specific work out of the lifework. As a result of this method the lifework is preserved in this work and at the same time canceled.[61]

First, the monad is a moment of recognition of the union of opposites—time and timelessness. In my work for instance, the monad is a theory of materiality that traverses the distance from alchemical transmutation to contemporary digital media. I am not as interested in whether or not Benjamin believed in an ultimate Messianic cessation of time. His great insight is to isolate this western longing as a fetishized desire that is intimately bound with the mechanics and economics of material production. The "blasting" of one collection of cultural practices out of yet another, in terms of separate historical periods, induces an analysis of the secret kinship between seemingly disparate time periods. To both preserve and cancel a moment of cultural and economic production describes the dialectical move. For example, Benjamin uses the example of fashion in terms of its dialectical valence. At the same time that one recognizes the ephemera of the fashionable, one likewise intuits its persistence. Fashion refers to the rapidly changing surface components that nonetheless 'hide' an abiding and enduring temporal law. Benjamin's theory, as I have indicated above, has been crucial to my method of drawing a connection between contemporary practices and pre-modern ones. Both of these seemingly incongruent

[60] Walter Benjamin, "Theses on the Philosophy of History," in *Illuminations*, ed. Hannah Arendt (New York: Schocken Books, 1955).
[61] Ibid., p. 263.

practices of alchemy and digital animation are gathered together under the techné' of material production.

This project is also indebted to Benjamin's theory of aura. In "The Work of Art in the Age of Mechanical Reproduction," Benjamin argues that the machinery of mass industry destroys the aura of authenticity that inheres in an original, hand-made, work of art. This article is sometimes interpreted negatively, as an indictment of modern technology. The tendency is to interpret aura as something that has been 'lost' through material reproduction. On the contrary, aura is dependent upon a temporal and spatial situatedness. In other words, aura is not a 'thing' to be identified visually. Rather, aura functions more as a sensation of nostalgic longing felt by the perceiver. For instance, in a footnote to this article, Benjamin makes the provocative claim that aura does not come into play until mimetic machinery produces it. "To be sure, at the time of its origin a medieval picture of the Madonna could not yet be said to be 'authentic.' It became 'authentic' only during the succeeding centuries and perhaps most strikingly so during the last one."[62] It is spatial and temporal distance that produces aura.

This is not to say, however, that the conception of aura is entirely abstract or subjective. Benjamin means something more akin to a pre-modern metaphysics of perception whereby the thing and its observer are 'one.' The aura is rendered insubstantial only because it requires a perceiver. Susan Buck-Morss does a good job of explicating this idea. "Benjamin's point is that, whether it is expressed allegorically (as eternal passing) or symbolically (as fleeting eternity) temporality enters into every experience, not just abstractly as Heidegger would have it, as the 'historicity' of Being, but concretely. That which is eternally true can thus only be captured in

[62] Benjamin, "The Work of Art in the Age of Mechanical Reproduction," p. 243.

transitory, material images of history itself."[63] Aura is therefore not produced along with the work of art, but is the effect of a temporal process in that it transpires at a later date, after technology has rendered its authenticity unstable. Now the work can be copied almost perfectly, but not quite, since its unique place in time and space can never be replicated. Benjamin points out that aura is created by technologies of representation that play a key role in placing humans at a remove from the seamless artifacts they produce. The illusive co-mingling of presence, perception, and distance produces an absence that, at its very core, signals loss, death, and absence.

Buck-Morss has provided an explication of Walter Benjamin's *Arcades Project.* She describes Benjamin's theory of the dialectical image which attempts to synthesize a materialist historiography with culture, politics, and metaphysics. The dialectical image is a sign, object, or artifact of modernity that is "charged" with political and cultural meanings. It is a particularly important concept for my project because it elaborates a theory of how old mythic forms linger within the products of cutting edge mechanical or technological production. Buck-Morss explains that the dialectical image embodies materially a repetitive temporal cycle in that it retains the objective stamp of historical changes. According to Buck-Morss' interpretation, that which is eternally true can only be captured in transitory images and things. Benjamin unpacks this theory by making reference to a complex of historical constellations. Some of these trajectories include theories of temporal logic of fashion, the fossil, and the mythic images, all of which are simultaneously condensed within the dialectical image. One of the historical valences described by Buck-Morss is ancient history.

[63] Susan Buck-Morss, *The Dialectics of Seeing: Walter Benjamin and the Arcades Project* (Cambridge, MA: The MIT Press, 1999).

Through an archaeology metaphor, Benjamin elaborates a theory of the fossil. The fossil, true to its original meaning, signals the remnants of a bygone era. These remnants are, paradoxically, visibly present in artifacts of mechanical production. The residual, skeletal structure of the old form is crucial to Benjamin's theory of history. One of Benjamin's examples of a fossil in the *Arcades Project* comes from the advent of new building materials. When iron became widely available, it was unnecessarily festooned with Baroque ornamentations such as flowers, vines, and filigrees. "Under the archaic masks of classical myth and traditional nature, the inherent potential of the 'new nature' within machines and iron shaped by new processes, technologies and materials of every sort, remained unrecognized, unconscious. At the same time, these masks express the desire to 'return' to a mythic time when human beings were reconciled with the natural world."[64] The point is that, no matter what era, Medieval, Victorian, or the twenty-first century, each epoch makes sense of new cultural forms by referencing the old ones.

The fossil is produced through the inexorable law of fashion. The moment of exposure for a new technological form emerges as the golden alchemical substance after the old form has been burned away. Yet, as we learn from Paracelsus, more and more procedures follow in endless succession and one is never entirely sure which part is the gold and which is the waste. According to Benjamin, a new cultural artifact is already a fossil at the moment of its emergence because it necessarily combines past and present. The hollowed-out shell of the commodity form displays the residuum of the flow of history. The skeletal 'excess' of the past congeals around the now decayed physical body.

Walter Benjamin elaborates a metaphysics of the commodity form whereby a temporal logic informs the persistent reemergence (albeit in different manifestations) of the law of fashion. In a sense, fashion becomes for Benjamin, what potential form was for Aristotle. Buck-Morss

[64] Ibid., p. 111.

identifies an important aspect of Benjaman's theory that resonates for contemporary cultural production. She claims that, "The short half-life of technology and commodities rapid turnover in style and consumption was experience in high capitalism as extreme temporal attenuation."[65] The new defines itself only in comparison to the archaic. In fact, it relies on the outmoded to earn its status as 'new.' The effect of this relationship is that even the new is always and already doomed to fall out of fashion.

One manifestation of the dialectical image, however, is its potential to lull the subject into somnambulistic fantasizing. If natural history, figured in the fossil, reveals a temporal process, then made-made myths mask them. The problem with mythic images is that they masquerade as natural objects. Benjamin refers to these images as "wish images," and describes them as the "phantasmagoria" of spectacle and advertising. Mythic images are dialectical in the sense that they propel the embodied subject into the future while, at the same time, they also relentlessly drag the subject backward via nostalgic longings for bygone days. In the sense that these images appeal to the 'natural' they produce mournful recollections of the past, permanently erased by the new, at the same time they seduce the subject to embrace the new.

> The paradox is that precisely by giving us nostalgic mimicking of the past and paying strict attention to the new nature, the ur-images are re-animated. Such is the logic of historical images, in which collective wish images are negated and surpassed, and at the same time dialectically redeemed . . . The moment of sublation reveals itself visually as an instantaneous flash wherein the old is illuminated precisely at the moment of its disappearance. This fleeting image of truth is not a process of exposure which destroys the secret, but a revelation that does it justice.[66]

In the force field between the fossil and the mythic image lies the potential for political redemption.

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[65] Ibid., p. 65.
[66] Ibid., p. 146.

In terms of a political process, individuals embrace exciting new epochs full of promise and potential, yet these revolutions are fueled by gazing backward in a hopeless desire to preserve what is gone, and ahead to a utopia that will always be just out of reach consistent with the metaphysics of deferral. New technologies that are supposed to actuate these revolutionary new moments in human history, are accompanied by this temporal logic of nostalgia. According to Buck-Morss, "By attaching themselves as surface ornamentation to the industrial and technological forms which have just come into existence, collective wish images imbue the merely new with radical political meaning, inscribing visibly on the products of the new means of production and ur-image of desired social ends of their development."[67] Since the past is visible in the object, it potentiates a "revolutionary shock" that will wake society from its slumber. This passage underscores Benjamin's political motivations in developing a theory of the commodity form. Far from suggesting that we are all duped by fashionable new objects and products, he suggests that commodities can potentiate political redemption.

The aspect of redemption in Benjamin's philosophy ensures that his theories cannot be read as alienation narratives within a classic materialist pedagogy in order to argue that capitalism has destroyed art or, more to the point, materiality in a commodity culture is complicit with a dominant ideology and therefore suspicious. Benjamin accepts the lowly commodity on its own terms. Perched precariously on the "trash heap of history," the commodity enjoys central importance in a philosophy that considers excess and residue central to cultural and historical processes rather than peripheral to it. He argues that the fossil in both its mythic and natural frames produce a "spark of recognition," in the unchanging or eternal (Messianic) within that which changes (temporal objects or fashion). It is this recognition that affords political transformation in the subject. According to Buck-Morss, this 'spark' is created in the 'tension-

[67] Ibid., p. 117.

filled' zone between past, present, and future. "Far from restraining the new within the given forms, they reach back to a more distant past in order to break from conventional forms."[68] Benjamin's philosophy is firmly grounded in material objects that are ubiquitous in, but not limited to, modernity. The commodity is not merely congealed ideology, it contains within it the seeds of potential recognition of temporal recurrence; that everything old becomes new again and vice versa. As a hypostasis of social relations, the commodity serves a pedagogical role.

As John Peters identified within Plato's thought, there is a lingering desire to get closer to organic reality, whether that reality is a tree or another human body. Benjamin refers to this as the wish to "pry an object from its shell," i.e., to discover its mysteries. According to Benjamin, who borrows extensively from Hegelian metaphysics, history enters materially into every object, specifically into commodities and other artifacts of cultural production. But Benjamin, writing during a tumultuous political epoch in Europe and looking back to the nineteenth century was talking about the era of industrialism and photography. What possible insights can he have for our era of electronic and digital representation of late capitalism? Benjamin theorizes the way in which technological artifacts signal, not the coming of a new epoch, but the "transiency of newness itself." According to Buck-Morss, "Computer Graphic images simulate these qualities through efforts to 'dream' again of the lost sign. To recapture the genuine through an artificial mastery of the real—only exposes inauthenticity."[69] Benjamin's identification of these timeless laws helps us to understand why people talk about technology in similar ways during widely separate historical moments. For instance, both television and the Internet were ushered in among hopeful speculation that they would not only serve democracy, but bring about its fuller realization and perfection. As many media scholars have noted, the frenetic pace at which

[68] Ibid., p. 116.
[69] Ibid., p. 129.

commodity forms are replaced (their shelf-life) bespeaks an underlying logic that remains static, the law of fashion itself. Benjamin's approach is both theoretically robust and refreshing because it approaches the metaphysical problem of new technology in a manner that avoids the worn out extremes of utopian and dystopian discourse. Benjamin offers an explanation of technology as the "new nature" and as such argues for its potentially redemptive qualities.

The artifacts of digital media are technologies of transformation that render visible "the ghosts of humanity" that are unnerving, indeed uncanny. Benjamin lingers extensively on technological innovation and its role in both borrowing the form of its ancestors at the same time it renders them obsolete. The flux of 'fashion' is forever a symbol of death since it signals the ceaseless logic of temporality—death and decay. We hope that our technological tools will grant us immortality, but in that granting we likewise glimpse our own demise. Digital design also borrows the recognizable form from a prior epoch, even when those forms fail to access the power of the new medium. The hollowed out shell of the "outmoded" or unfashionable congeals around the most cutting edge technologies. The metaphysics of temporality and transformation elucidated by Benjamin is also applicable to traditional alchemy. Part of the reason why old forms cling to new ones is due to the fact that we can never entirely relinquish the residual aspects of artificial replications of natural rhythms.

Benjamin gets us a theory of representation suitable to new forms like digital animation. For Benjamin, representation is dynamic and transformative. It involves the image and 'looking' but significantly, it also implies an embodied, material, and tangible experience, a continuity between subject and object that gestures back to a forgotten but sublimated worldview. At the same time, however, his theory of representation is capable of accommodating the unique technological forms of contemporary culture. Technological artifacts, whether these are

photographs or digital images, are caught in a temporal force field whereby the past is used to make sense of the present.

In the literature review, I discussed new media technologies broadly in terms of the theories surrounding media like cyberspace and virtual reality. However, in what follows I will describe the particular objects, texts, and methods with which to critique them in the following chapters. I will argue that the line between organic reality and digital copies of organic reality remains firmly drawn. This is due to the fact that a material residue or remainder is produced during digital representation that, as in alchemical practice, flags the artificiality of the process. I examine my examples as objects, even if they happen to be virtual, or in other words, digital designs. How does one examine the materiality, in addition to the textuality, of digital object? Within this dissertation, representation is a process that always hails its own artificiality via its material byproducts. A concept of materiality in terms of 'actual thingness' is crucial to this argument since I do no refer to material byproducts as texts, symbols, or signs but as unique harbingers of the process of copying nature. Understood this way, representation is partially symbolic and partially material. In short, artificiality is not merely an aspect of perception, but a physical characteristic that inheres in the object or image itself. In my view, the fake copy always reveals itself via its form and not merely through its function as a sign whose meaning depends on the manner in which it points or refers to something else. Within the nexus of constantly shifting cultural conventions that comprise language, meanings rest on a largely unstable and highly subjective terrain. I do not challenge this theory of language. However, I wish to argue that simulation does not collapse the real and the artificial, and that virtual reality is not only firmly distinct from 'reality' but also increasingly detectable by audiences. Therefore, my project requires an alternative methodology than a traditional semiotic approach. I want to address the

problem of how we continue to assert that it is precisely the domain of reality that is being challenged by new media, while at the same time disallowing our theoretical rubrics from tackling that very problem. This is an attempt to craft a theoretical tool with which to critique the unique aspects of digital objects. The conclusions that I draw as a result of this approach could not be arrived at faithfully if digital artifacts are viewed merely as byproducts of social, economic, psychological, or cultural forces.

Within a very large collection of disciplines, industries, and practices within the general category of new media studies, I have narrowed my scope to examine the practice of designing digital texts. I confine my study to accessible examples from Hollywood film and SIGGRAPH conference literature that demonstrate the various innovations within the field of digital animation and computer graphics. Most importantly, I limit my examples to those that illustrate the field's all encompassing goal of achieving photorealism. In addition, I will examine literature on interface design, since it is the tool of the interface that has been transformed over the years in order to produce more and more realistic-looking digital objects. In general, I focus on production practices in order to illustrate the link between digital design and alchemical transmutation, which is also a process of artificially manipulating organic reality.

In order keep my philosophical and theoretical points from becoming unhinged from my objects of study, I ground these observations in an examination of the trade literature of digital designers in order to show that these individuals do not follow a lock-step rhythm to further the aims of global capital or technological tyranny. In order to avoid essentialist or technologically deterministic narratives, I therefore examine the language, practices, and artifacts of digital animators and filmmakers. In this way I hope to do justice to the material reality that initiates so much metaphysical speculation about the technology. In other words, I do not wish to submerge

the technology beneath contextual forces in order of importance. But I also hope to garnish this interest in the material reality of digital artifacts by taking into account the context or conditions of technological production in order to avoid abstract guess-work concerning the philosophical and metaphysical issues that digital technology raises. As mentioned previously, two theories that inform my thinking about cultural artifacts are Aristotle's theory of a twofold aspect to all material things, and Walter Benjamin's dialectical image, which I largely plunder for its insights on the relationship between time and matter.

In keeping with my insistence that we consider the materials and practices of digital design, Chapter 1 of this dissertation begins with an explication of the computer graphics industry's professional standards for digital animation. The history of digital animation and computer graphics has been driven by a quest for photo-realism. I conclude that the closer practitioners get to reaching this goal, the further away it slips. The desire for photo-realism is a fetishized and unattainable object. The inability to finally attain photo-realism involves the process of innovating new techniques which raise new problems as soon as one is resolved.

Chapter 2 deploys a similar method in examining the goals and failures of interface design for computer graphics. In this instance, the goal is to transcend the material limitations of the human body and the recalcitrance of real-world artifacts. Interface design is a curious practice worthy of examination in light of a history of metaphysics because it seems that designers wish to pile up layers of technology in order to pretend that, in the end, there are no artificial restraints to accessing organic reality. Yet, the use of technologies of mediation to access 'reality' is hardly a new concept in human history. What is remarkable, however, is that its link to ancient examples with the same goals and claims has been largely ignored.

Chapter 3 of this dissertation demonstrates that the goals of realism and transcendence are ancient ones. To understand the cultural consequences of these contemporary practices we need not turn to the dawn of storage media in the nineteenth century, but to the ancient practice of alchemy—particularly to the work of Paracelsus. The great virtue of Paracelsian alchemy is that it spells out the metaphysics of deferral brought about through the practice of transmutation. Alchemy serves as an example of early thinking about virtual reality and artificial simulation. Alchemical transformation is a proto-typical moment in thinking about the nature of artificial self-augmentation through the crafting and manipulation of material reality.

Chapter 4 combines the insights in the first two chapters through a theory of digital alchemy in which I critique the goals of realism and transcendence in the computer graphics industry by assessing their failure in the first full-feature, digitally-animated film, *Final Fantasy.* I place the idea of endless deferral in digital texts in conversation with alchemical deferral to show that metaphysical speculation is possible in contemporary media because of a long-term preoccupation with unreachable goals of transcendence. Most importantly, these goals are instantiated in cultural artifacts materially and are therefore, not just a social phenomenon. Using Walter Benjamin's theory of aura, I argue that cultural artifacts retain the material stamp of abstract historical forces. Like alchemy, digital design is a process of endless separation, abstraction, and convergence. Both practices are centrally concerned with the nature of artificial augmentation and simulation. The result of such goals however, is endlessly deferred as the practitioner ends up with more and more trash or residue rather than less (as implied by the logic of transcendence).

This idea of endless deferral is addressed in the following chapter. I turn now to the standards of realism generated by the computer graphics industry and their professional

practices, showing that each new innovation creates pressure to realize even higher levels of photorealism.

2.0 CHAPTER 1:
THE ELUSIVE LIFE FORCE: THE QUEST FOR PHOTOREALISM IN THE COMPUTER GRAPHICS INDUSTRY

Leading scholar of digital technology, Lev Manovich argues that the combination of traditional media and computers entails a unique crystallization of prior media conventions; most notably film. He claims that, "element by element, cinema is being poured into a computer."[70] Indeed, many of the icons in a traditional computer animation program display the familiar devices of camera angles, point of view, and lighting. Digital animators produce texts that are guided by traditional cinematic frames of reference. For instance, many "first person shooter" video and computer games, as in film, invite the audience/player into a virtual world by pairing human perception with a technological lens. The audience's gaze becomes synonymous with the camera, looking out at other characters and scenes. First-person camera angles do not ask the audience to occupy the point of view of another character. Instead, they render the relationship between the audience member and the technological apparatus transparent by pretending to collapse them.

Manovich explains that what sets digital representation apart from the analog coding or continuous data used in film is that media objects can now be expressed mathematically and as such, can be broken into discrete units or modules which render these objects more malleable. Further, he sees this as a process of abstraction and disembodiment. "In the process of this translation [from analog to digital], cinematic perception is divorced from its original material

[70] Lev Manovich, *The Language of New Media* (The MIT Press, 2001).

embodiment (camera, film stock) as well as from the historical context of its formation."[71] However one could just as easily claim that this transition is itself historically grounded in the metaphysics of representation. The question then, is not necessarily that film conventions in the digital realm merely operate as familiar ways to organize a new medium; rather, they reassert the metaphysical problem inherent to all forms of technological or artificial representation including literary texts and the visual arts. What is at stake here is the relationship between reality and representation and the role of media in rendering that relationship as transparent as possible. Therefore, pointing out the ways in which computers are borrowing and altering film conventions is useful, but it forecloses an analysis of other pairings that illuminate the cultural applications of computer artifacts like animation software.

Manovich also argues that film conventions are used metaphorically rather than materially. This claim must also be qualified since the practitioners of digital animation view their work in terms of material production. Objects, characters, and scenes are treated as if they were real, even if they only exist in a virtual space. When digital animators and interface designers use the term "metaphor," they are actually referring to the design and implementation of software programs. The primary metaphor that motivates software design in the industry is the term "intuitive." Intuitive design reflects the goal of making interfaces easier to use for non-experts. The layout of a typical interface, therefore, is organized around the depiction of familiar objects and actions like a file folder, a trash bin, a hand that grabs things, a paint brush, etc. Metaphor always entails a material component in the business of digital animation. In very important ways, the line between metaphor and materiality in digital production is a hazy one at best. This is because digital animation is not so much a space of making texts, as it is a space for making and *manipulating objects* that are both "real" and simulated. As many scholars have

[71] Ibid., p. 86.

noted, our linguistic categories, as well as our ontological ones falter before the virtual. I wish to argue that digital production does, in fact, resurrect old problems, just not necessarily those related exclusively to cinema.

There are several ways that digital production departs from traditional film conventions. First, although the goal of realism drives the computer graphics industry, the malleability of digital technology and the abilities of computing, make those goals more substantive, even biological. In other words, animators and designers are not just trying to represent the real; rather, they wish to harness the essence of life itself. They attempt to write algorithms that will mimic the laws of nature and physics such as kinematics, plant growth, systems behavior, flight, and many more.

Digital production also differs from film in that it is capable of surpassing the traditional roles of film. This is obvious in the cases of global illumination and virtual camera. According to one professional, "In order to achieve realism, animators would have to abandon all the tricky lighting instruments and rely on the same lighting physics of the real world. In the real world, light enters a scene and bounces around a long time."[72] There is a rich history of the development of lighting effects in the computer graphics industry. Designers do not follow film conventions but create algorithms for reproducing the characteristics of real light, e.g., they do not use virtual 'light bulbs' but the 'sun.' Animators seek to re-introduce the imperfections and 'mistakes' that occur in 'reality' during film production. "In real-life photography, flares are considered an undesirable side effect of lighting and photographic lens design. Animators, however, tend to employ lens flares and other kinds of flares as a means of building the credibility of reality."[73] Interface design in virtual reality, augmented reality, and computer animation is a process of

[72] George Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya* (New York: McGraw Hill Co., Inc., 2004).
[73] Ibid., p. 283.

explaining to a computer, in mathematical language, what you want it to 'draw.' This process of communication between human and computer is referred to as rendering. Contra Manovich, sophisticated rendering software is eliminating dependence on traditional film conventions within the realm of digital film since;

> The complexity of lighting is currently migrating from the user's skilled hand to the rendering engine's domain. Some traditional animators are resisting this trend . . . Many game developers are loath to abandon their Hollywood-inspired lighting tools, but the advance of technology, its ever-improving capabilities, and the pressure of producing good work with a limited budget are driving everyone to accept the rendering engine as an indispensable tool in lighting.[74]

Increasingly, digital representations take the organic world and physical laws as their point of comparison, and not technologies like photography, film, and television. In fact, professionals are experimenting with lighting techniques through which "the user may be offered the ability to enter the calendar date, time of day, and geographical location, whereby the computer will automatically calculate the precise position of the sun during the course of your animation."[75]

According to Manovich, digital technology ushers in a new era of automation in the production of media artifacts. He argues that the digital era is not exempt from the assembly line logic of its forbears whereby time and money is saved when each stage in the production process is divided among separate phases and people completing those phases. In one sense, the process of creating faster and more powerful rendering engines means that the capitalistic equation is an accurate model for the computer graphics industry. Increasingly, labor-intensive jobs are accomplished through computing power and complex procedures are simplified by intuitive interfaces. "In Hollywood films, flocks of birds, and colonies, and crowds of people are

[74] Ibid., p. 273-274.
[75] Ibid., p. 273.

automatically created by AL (artificial life) software."[76] While it is true that hardware and software development have streamlined laborious animation procedures, it is also true that few animators, teams of animators, and the production houses that employ them, are *seldom satisfied with the level of realism* they achieve, particularly large companies like Pixar and Industrial Light and Magic. "The bean counters in Hollywood—who like to think technology means cheaper movies—wonder if *Toy Story* will eventually make animation more efficient . . . But artists like Lasseter and Docter won't be satisfied the next time around to repeat the relatively simple shots of *Toy Story.*"[77] Also, a film like *The Lord of the Rings* employs thousands of individual animators for intricate jobs like making foliage or facial expressions. These tasks remain formidable in that they require a great deal of artistry and technical knowledge; two types of knowledge that are rarely found together in a single individual. Nevertheless, to describe this process as analogous to an assembly line mode of production is inaccurate. Digital design, even if produced via a team of laborers is not streamlined and doesn't necessarily make film production easier. Digital texts differ markedly in quality, showing that there is no pre-molded 'stamp' designed to churn out a large number of identical copies.

Further, the film industry gets a lot more attention from scholars, journalists, and the public. Yet a significant amount of digital production takes place in educational, scientific, and medical contexts; to name just a few. Due to the increasing accessibility of animation programs like *Maya,* and the affordability of high speed technology, individual, freelance animators can enjoy a thriving business. But for these practitioners, animation does not amount to automation. It remains painstaking work. "Animation doesn't mean automation. Each second has to be

[76] Manovich, *The Language of New Media*.
[77] David Kaplan, "High Tech in Toon Town: Why the Computer-Generated Hit *Toy Story* May Change the Business of Animation Forever," *Newsweek*, Dec. 4 1995.

programmed manually."[78] Most digital animation software programs, though comparably easier to manage than complex mathematical algorithms, are nonetheless technically sophisticated, offering both depth and breadth in the often bewildering amount of tools available to the end user.

This is not to say that the goals of efficiency and speed are not important factors as they are in any capitalist system. While it is true that short cuts built into the software allow beginners and experts alike to access a database of pre-designed imagery and objects, it is also true that the industry makes more work for itself due to an almost monomaniacal quest for realism. No sooner does one short cut take shape such as ray tracing (a lighting effect) than another is engineered to take its place. It is possible that this is a phase that will reach its zenith and fizzle out (thereby rendering my work obsolete!). Currently, however, both software designers and the digital animators that use this technology, find that realism is tantalizingly out of reach.

Manovich's work combines prescient insights into digital technology with predictable rehearsals of film theory since he assumes, along with many scholars of media, that if we cannot claim that new media technologies usher in a revolutionary era, then we must show how they follow in the wake of their technological forbears; especially in terms of the economic realities of the industry that drives production.

The following chapter will examine the problems raised by Manovich and other scholars of new media by addressing the metaphysical issues at the heart of technological representation. I will examine the texts within the computer graphics industry in order to address the question of historical continuity versus revolutionary rupture, the issue of reality and representation, and the elusive goals of reproducing life. I summarize the history of digital animation techniques, as well as current practices by looking at convention proceedings, trade magazines, "how-to" manuals,

[78] Ibid., p. 54.

popular digital texts, and artifacts of digital design. I turn to the producers of digital texts themselves in an attempt to reveal a link between metaphysical, social, and historical speculation. This chapter examines these theoretical issues via an analysis of the goal of photorealism within the computer graphics industry since the struggle to create realistic digital texts is closely aligned with the material aspects of digital technology. The chapter concludes with an argument that will carry over into subsequent chapters: the goals of realism are constantly receding. In other words, each technological innovation that brings digital practitioners closer to their goal not only raises new problems, but instantiates within the digital texts produced an aura of artificiality.

The history of the computer graphics industry is marked, as are most histories of technology, with false starts, dead-ends, lots of tinkering by privileged men in elite academic institutions, and plenty of funding from the government (and the military).[79] The last 30 years of computer graphics history is quite complex and is thoroughly permeated by a myriad of contextual and material forces. In other words, the development of computer graphics reveals a constant interplay between experimentation and the cultural and economic contexts that actively shape the technological artifacts produced through that work. Most early efforts at graphics took place in the rarified environments of engineering laboratories at universities and corporations like Bell Labs, GE, and Boeing. Since this dissertation is devoted solely to digital history, I include here only those facts and examples that are relevant to showing the development of the goal of realism. Therefore, many of the details of this history are left out such as the issues of corporate and government funding, the major academic institutions involved in the development of computer graphic interfaces, the growth of private computer graphics studios, and the concomitant growth of virtual reality and artificial intelligence. I have eliminated many of the

[79] See Winston, *Media Technology and Society: A History from the Telegraph to the Internet*.

complex contextual forces that influenced the particular artifacts and innovations of the computer graphics field in important ways because, in keeping with my goal of assessing micropractices on the ground, I will avoid making more generalized claims about the larger social climate that produced these digital texts.

Most of the major innovations in digital representation began long before the public started to notice the proliferation of special effects in film and on television. This is another common feature of technological development. Applications (uses for consumers) occur much later than the original invention because scientists and engineers can rarely anticipate how a particular technology will be used to benefit individuals or institutions. Throughout the 70s and 80s the groundwork was already being laid for the breathtaking realism that we witness today in films like *Final Fantasy* and *Lord of the Rings.* In fact, historians of computer graphics consider Ivan Sutherland's *Sketchpad,* completed at MIT as his Ph.D. project in 1963, as an important moment in the field of computer graphics since "the user could input simple lines and curves by drawing directly on the screen with a light pen."[80] In other words, a human could interact with a computer by 'drawing' two-dimensional objects directly onto the screen. Sutherland would later go on to work for the Department of Defense and create the first head-mounted display (HMD) at Harvard in 1966, to launch an era of virtual reality.[81] In some examples, such as mathematician Ben Laposky's electronic oscilloscope imagery, graphics were merely the byproducts of complex algorithms designed to help visualize scientific and mathematical information.[82] "In the early days of interacting with the new digital computer, sometimes investigations into issues such as complex math formulas or ergonomic design resulted in visual

[80] Terrance Masson, *Cg 101: A Computer Graphics Industry Reference* (Indianapolis: New Riders Publishing, 1999), p. 396.
[81] Ibid., p. 396.
[82] Ibid., p. 390.

images produced on the computer that have remained in our discipline as contributions to art."[83] However, artful or not, scientific visualization produced images that were considered to be achievements in their own right due to their novelty. As Bolter and Grusin have shown using the early interactive game *Pong*, early computer graphics techniques suggested new scientific, cultural, and social applications for computers.[84] However, the collapse of art and engineering in the computer graphics field remains strong today, as software designers and digital animators contribute short films to SIGGRAPH's much celebrated electronic theatre. These contributions are filed away in the archives as examples of the many individual techniques that line the path toward realism. As with the history of film, those who tinkered with the technology (writing coded programs for use by computers) were also content creators due to the complexity of the process. All early computer graphics were created through complex mathematical algorithms which were inaccessible to those not trained in computer programming. There were no ready-made interfaces for creating computer graphics as there are today.

Yet even early in computer graphics history, animators were united in their goal of representing objects and their surface imperfections as realistically as possible. In the digital realm, realism refers to the illusion of reality created through the accurate representation of minute textures, tissues, fabrics, skin, and surfaces. Within the vast repertoire of disciplines, techniques, purposes, and tools that comprise the computer graphics field, all are linked by the common goal of achieving a fidelity to the real world, whether that real world is a human figure, a cloud, the texture of paint, the process of erosion, or the muscle structure of an alien being. One historian of computer graphics states that, "one of the keys to complex realistic images is to represent the laws of nature and the physical environment in such a way that they are reasonably

[83] Wayne Carlson, *A Critical History of Computer Graphics and Animation*, (Ohio State University, 2004).
[84] Jay David and Richard Grusin Bolter, *Remediation: Understanding New Media* (The MIT Press, 1999), p. 90.

accurate and consistent, yet approximated in such a way as to allow reasonable computation speeds."[85] It is not an exaggeration to say that the goal of realism is to fool the eye by convincing the audience that what they are watching are real crowds, characters, and scenes. While this is obviously impossible when making an alien, producers of films like *Spiderman* brag that audiences could not tell the difference between the real actor and the digital doppelganger. "In Spiderman, the filmmakers actually 'fool the eye,' says Alias/Wavefront president Doug Walker, by switching between a computer-generated Spiderman and a costumed Toby McGuire or stuntman. 'None of us can tell which is real. It's gotten to the point where if the computer graphics artist can imagine it, it can happen.'"[86] Despite the boasting, however, the trend toward undetectable scenes and objects remains an elusive goal in reality. More often than not, audiences can identify digital effects in a film and their perceptual savvy grows in proportion to the ubiquity of these images. Whether or not digital technology is capable of perfect copies of nature is a problem that critics and scholars frequently puzzle over. It is more important to ask why this is the case, why this obsession with realism, rather than to evaluate the industry based on its success or failure in achieving these standards of realism as so many film reviews and popular magazines do.

The professional organization, Special Interest Group on Computer Graphics (SIGGRAPH), has published hundreds of articles on the history of achieving realistic computer representations.

> Since the first SIGGRAPH conference 25 years ago, the quest for greater expressiveness through silicon has eked out incremental triumphs: from spindly wire-frame graphics to form-defining texture mapping of surfaces. Computer graphics artists first captured the subtle ways that light is reflected from surfaces, later perfecting the visual melding of morphing. Along the way come

[85] Carlson, "A Critical History of Computer Graphics and Animation."
[86] Mike Snider, "3-D Technology Maya Muscles Its Way into Hollywood," *USA Today*, March 20 2003.

> marvelous breakthroughs in realism, in effects such as the shimmering of water and the behavior of particles in smoke and fire.[87]

For digital designers, the annual SIGGRAPH Conventions, for instance, are venues whereby the standards of realism in the field of computer graphics are presented and formally judged by professionals in the field.[88] The convention hosts a 'digital theatre' studio where competitive clips of digital animation films and "shorts" are shown to an enthusiastic, yet highly discerning audience. Although digital film makes up a small percentage of the computer graphics industry, understanding the role that digital special effects play at large conferences like ACM SIGGRAPH Computer Graphics provides an accessible entry point into the multifarious array of computer objects, applications, and operations included in the professional organization at large. Some recent well-known Hollywood blockbusters that were exhibited by computer engineers and digital animators at SIGGRAPH's computer graphics conventions include: *Star Wars I: The Phantom Menace, Shrek,* and *The Lord of the Rings: The Two Towers.*[89] These films demonstrate how, over the years, innovations in modeling and rendering have greatly enhanced the repertoire of processes, textures, objects, and characters that can be created in virtual space.

Realism encompasses an array of attributes including, "shape, color, surface texture, luminosity, (interior light source), reflectance (the amount of light that the surface bounces back into the scene), specularity (the shininess of the object), mass (the weight of the object), and

[87] Steve Ditlea, "Cloning Around," *Technology Review* 102, no. 1 (1999), p. 84.
[88] SIGGRAPH, *Electronic Art and Animation Catalog/Siggraph* (New York: Association for Computing Machinery, 1998-2004). Examples of digital "shorts," and artwork demonstrating innovations in photorealism. These are also available on DVDs.
[89] Yves Metraux, "Star Wars Episode 1: The Phantom Menace" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Los Angeles, CA, 1999), "Shrek" (paper presented at the ACM SIGGRAPH 2001 Video Review on Electronic Theater Program, 2001), Remington Scott, "Sparking Life: Notes on the Performance Capture Sessions for the *Lord of the Rings*" (paper presented at the ACM SIGGRAPH Computer Graphics, November 2003).

resilience (the hardness of an object)."[90] Questions of texture and movement are big concerns for animators. Will the clouds move? How will grass respond to a character walking through it? Will the branches and leaves on a tree move? How deep and clear will the body of water be? These are just some of the seemingly mundane problems of real world physics that animators must take into account.

Realism is a term that has been studied and practiced for a long time, particularly among scholars of art, literature, and film. As noted by Lev Manovich, the computer graphics industry has borrowed traditional conventions of realism from the film industry. But what, precisely, does realism mean for the computer graphics industry? This is an important question since it is a notoriously difficult aesthetic term to define. Within film, realism generally refers to the illusion of resemblance created through the camera apparatus. In other words, film uses certain technological conventions to create seamless images and movements. The first of these "mechanical systems of production," according to André Bazin, was the illusion of three dimensional space in painting during the Renaissance.[91] Bazin refers to perspective as a long standing tradition in all of the "plastic arts." This view of realism continues to exert an influence on the field of computer graphics today, just as it did on painting, photography, film, and television. Computer graphics professionals also seek a seamless illusion of three-dimensional reality artificially generated by a computer.

More recently however, realism refers to the behavior of computer models versus their pictorial accuracy. This fact contributes a new layer to the history of realism in that the advent of computers allows representations to be imbued with a level of artificial intelligence and autonomy. In other words, the illusion of realism which was once so dependent upon the rapid

[90] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 30.
[91] André Bazin, *What Is Cinema?* trans. Hugh Gray (Berkeley: University of California Press, 1967, p. 10-11.

display of still images in succession, is now produced by attempts to harness in mathematical terms the law or 'codes' governing organic movements of transformation. This means that digital animators wish to skip the traditional procedures for creating illusions and ambitiously, access organic reality directly. Although, as in film, they use technical shortcuts to do so.

An obsession with the minutia of physiological effects necessary to create realistic computer models is captured in one group of designers' interest in representing muscle fatigue. "There are still few methods to add physiological effects to motion which are caused by fatigue, injuries, muscle training and muscle shrinking. This is because the innate structure of the human body, such as the musculoskeletal system, has been mostly neglected when handling human motion in computer graphics."[92] These new technologies of representation introduce a technique of verisimilitude based on dynamic movement versus the formerly static (a succession of still images) way of representing the world. Computer graphics' melding with cinema may well alter theories of visuality and spectatorship (though such speculations concerning perception fall outside the scope of this work).

Realism in the computer graphics industry is overwhelmingly driven by the goal of copying real-world phenomena. For example, the setting or scene in which characters engage in some form of action is usually subject to the same real-world constraints defined by the laws of physics. According to Watkins, "The most believable animation is the one that transcends the heavy technical requirements of animation to a level of organic movement."[93] Increasingly, organic movement is governed by integrating constraints or rules that "help mimic natural motion by providing a mechanism for controlling the position or orientation of a bone at any

[92] Taku Komura and Yoshihisa Shingawa, "Attaching Physiological Effects to Motion-Captured Data." Paper presented at the Graphics Interface 2001, Ottawa, Ontario, 7-9 June 2001, p. 27.
[93] Adam Watkins, *3d Animation: From Models to Movies* (Rockland, MA: Charles River Media, Inc., 2001), p. 3.

given time."[94] Leading researcher in this area, Demetri Terzopoulos, explains that future work in computer graphics and animation will be oriented toward creating objects that are essentially "alive."

> New graphics models have taken bold steps toward the realistic emulation of a variety of living things—including plants and animals—from lower organisms all the way up the evolutionary ladder to humans. Typically, these models take complex forms and inhabit virtual world in which they are subject to the laws of physics . . . But more significantly, these models must also simulate many of the natural processes that uniquely characterize living systems—including birth and death, growth and development, natural selection, evolution, perception, locomotion, manipulation, adaptive behavior, learning, and intelligence.[95]

Characters and scenes can now be granted a level of autonomy in a simulated environment that allows them to respond realistically to that environment. In short, the kind of computer graphics now being used in film and many other contexts is an amalgamation of several disciplines: art, biology, computer science and engineering, interface design, digital animation, virtual reality, artificial life (ALife), and simulation or information visualization. The cooperative efforts of each of these fields bring us the stunning effects showcased in such films as *Shrek* and *Lord of the Rings.* Yet it is important to emphasize that the field of computer graphics encompasses far more contexts than Hollywood film since computers are being used regularly in many scientific, medical, educational, artistic, and professional contexts.

There are generally three types of animation processes which I have grouped and named for explanatory purposes: cinematic, virtual, and real-time, all of which are devoted to the goal of realism and all of which begin with the modeling phase. These categories do not reflect the manner in which the field officially brackets off separate areas of research since these categories

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[94] *Learning Maya 5: Character Rigging and Animation*, (Alias/Wavefront, 2003).
[95]Demetri Terzopuolos, John Funge, and Xiaoyuan Tu, "Cognitive Modeling: Knowledge, Reasoning, and Planning for Intelligent Characters" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1999), p. 29.

are too numerous to name here.[96] Nevertheless, each type of animation is linked in that all must begin with a modeling phase. Cinematic animation comprises non-interactive (in terms of the end user) characters, scenes, and actions. Obviously, a film like *Shrek*, is meant to be watched as a traditional film. However, using the same character models designed for a particular film, producers can create interactive video games. This occurs in *The Matrix* and *Toy Story*, which were spun off into video games that fill in gaps and extend story lines. Rather than one static representation that is stored in a particular form, real-time animation is interactive. Each image within a game world, is based on a hierarchy of potential scenes and possible choices and is created and recreated anew within the player's temporal field. Real-time animation is one of the most rapidly developing fields in the computer industry because it has always been burdened by a need for computer power—power that was not always available.[97] Computer and video games

[96] ACM SIGGRAPH divides the computer graphics field as follows (although this is not an exhaustive list): Autonomous Agents, Deformable Objects, Information Visualization, Intuitive Interfaces for Animation, Modeling, Motion Planning, Natural Phenomena, Non-Photorealistic Animation & Rendering, Real Time Rendering, Reality Based Animation, Rendering, and Simulation.

[97] Neeharika Adabala, et al., "Real-Time Rendering of Woven Clothes" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, 2003), Christian A. Bohn, Volker Helzle, Sebastian Schmidt, and Florian Struck, "Realistic Shading of Human Skin in Real Time" (paper presented at the Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa, South Africa, 2004), Anton L. Fuhrmann, Stefan Maierhofer, and Robert F. Tobler, "Real-Time Glossy Reflections on Planar Surfaces" (paper presented at the Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa, South Africa, 2004), Michael Haller, Stephan Drab, and Werner Hartmann, "A Real-Time Shadow Approach for an Augmented Reality Application Using Shadow Volumes" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, 2003), Xuejun Hao, and Amitabh Varshney, "Real-Time Rendering of Translucent Meshes," *Transactions on Graphics (TOG)* 23, no. 2 (2004), Kazuhiro Hiwada, Atsuto Maki, and Akiko Nakashima, "Mimicking Video-Real-Time Morphable 3d Model Fitting" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, 2003), Adam Lake, Carl Marshall, Mark Harris, and Marc Blackstein, "Stylized Rendering Techniques for Scalable Real-Time 3d Animation" (paper presented at the 1st International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2000), Sang-Yup Lee, Ig-Jae Kim, Sang C. Ahn, Heedong Ko, Myo-Taeg Lim, and Hyoung-Gon Kim, "Real Time 3d Avatar for Interactive Mixed Reality" (paper presented at the ACM SIGGRAPH International Conference on Virtual Reality Continuum and it Applications in Industry, Singapore, 2004), Alexandre Meyer, and Celine Loscos, "Real-Time Reflection on Moving Vehicles in Urban Environments" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, 2003), Joshua Schpok, Joseph Simmons, David S. Ebert, and Charles Hansen, "A Real-Time Cloud Modeling, Rendering, and Animation System" (paper presented at the ACM SIGGRAPH/Eurographics Symposium on Computer Animation, San Diego, CA, 2003), V. Singh, D. Silver, and N. Cornea, "Real-Time Volume Manipulation" (paper presented at the Eurographics/IEEE TOG Workshop on Volume Graphics, Tokyo, Japan, 2003), Gabor Szijarto, and Jozsef Koloszar, "Hardware Accelerated Rendering of Foliage for Real-Time Applications" (paper presented at the International Conference on Computer Graphics and Interactive

often require special hardware (Xbox and Playstation) as well as video cards in order to run them.

Virtual animation or simulation, first used in the scientific modeling of ecosystems and in the behaviors of biological, chemical, and mathematical processes, also generates models and characters, but unlike cinematic animation or real-time animation, the "characters" are often endowed with a certain level of autonomy or artificial intelligence. This relatively new field in computer graphics is inspired by systems theory and ALife in the biological sciences. Autonomous agent graphics are used in the gaming industry, allowing players to develop their own living systems such as interactive family units or entire ecosystems.[98] In many ways, my characterization of the basic divisions in the graphics field is oversimplified. To some extent, all computer graphics are flexible virtual systems that can be manipulated by the original designer or an end user. Further, all are exemplary, to a greater or lesser degree, of an attempt to simulate the laws governing physical movement, weather, real-world textures, and other natural phenomena. It should be clear at this point that even though the industry is divided into different types of animation architectures with differing goals for end users, all are committed to realism.

There are two types of realism coveted within the field of computer graphics. The first is a realism which attempts to simulate the pictorial accuracy, including lighting and surface imperfections, of professional photography. This type of realism is called photo-realism. However, like all aesthetic conventions, the term is somewhat misleading and functions more as a professional standard or placeholder for professional goals than an explanation of what,

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Techniques, Budmerice, Slovakia, 2003), Jiening Wang, and Jizhou Sun, "Real-Time Bump Mapped Texture Shading Based on Hardware Acceleration" (paper presented at the ACM SIGGRAPH International Conference on Virtual Reality Continuum and its Applications in Industry, Singapore, 2004), Michael Wimmer, and Peter Wonka, "Rendering Time Estimation for Real-Time Rendering" (paper presented at the 14th Eurographics Workshop on Rendering, Leuven, Belgium, 2003), Ping Yuan, Mark Green, and Rynson W. H. Lau, "A Framework for Performance Evaluation of Real-Time Rendering Algorithms in Virtual Reality" (paper presented at the Virtual Reality Software and Technology, Lausanne, Switzerland, 1997).

[98] See *The Sims*, *Sim City*, and *Sim Ants* computer games.

precisely, photorealism is. "This is an arbitrary and misused term for a CG image that is indistinguishable from reality."[99] We learn that photorealism really has little to do with photography since photography itself does not inherently seek realism. Either for artistic purposes or quite by accident, film remains a technological medium of representation, not a window onto the world as it is. Computer Graphics professionals are not innocent of this distinction. What they mean by photorealism is an attempt to trick the eye into believing it sees an organically real thing rather than a simulated one. Whether or not the profession has achieved this goal, and what such a goal entails in terms of its assumptions about the relationship between reality and representation, will be treated at length later in this chapter. For now, it is important to note that photorealism is certainly deemed to be the driving force in the computer graphics industry. Recently, the pinnacle of success in achieving realism is considered to be the digital representation of the human form (particularly facial features)—the Holy Grail of digital design.[100]

Modeling human characters is widely accepted within the field as the most difficult technique to accomplish realistically and as a result, is also the least convincing to audiences. One animator observes that,

> Photorealistic characters must not only look real, they must also be animated realistically, which requires a lot of subtleties in character controls. Between these extremes is a surreal character

[99] Masson, *Cg 101: A Computer Graphics Industry Reference*, p. 156.
[100] Neil Campbell, Colin Dalton, David Gibson, Lisa Gralewski, and Barry Thomas, "Statistical Synthesis of Facial Expressions for the Portrayal of Emotion" (paper presented at the Computer Graphics and Interactive Techniques in Austalasia and South East Asia, Singapore, 2004), Douglas DeCarlo, Dimitris Metaxas, and Matthew Stone, "An Anthropomorphic Face Model Using Variational Techniques," *Proceedings of the 25th annual conference on Computer graphics and interactive techniques* 47, no. 2 (1998), Bruce Gooch, and Vidya Setlur, "Is That a Smile? Gaze Dependent Facial Expressions" (paper presented at the Non-Photorealistic Animation and Rendering, Annecy, France, 2004), Cindy Grimm, Brian Guenter, Henrique Malvar, Fredric Pighin, & Daniel Wood, "Making Faces" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Minneapolis, MN, 1998), Terence Sim, Chew Lim Tan, and Yu Zhang, "Rapid Modeling of 3d Faces for Animation Using an Efficient Adaptation Algorithm" (paper presented at the Computer Graphics and Interactive Techniques in Austalasia and South East Asia, Singapore, 2004).

> design, such as a Shrek-like character. This kind of character has a stylized look, while still containing a believable anatomical structure. Such a character is easier to model and animate because viewer expectations will not be as high as for a photorealistic character.[101]

For instance, digital animators for the film *The Matrix* had to make the virtual actors look identical to their real human counterparts. According to one designer, "The ultimate challenge in photorealistic computer graphics is rendering human faces. We are trained to study the human face since birth, so our brains are intimately familiar with every nuance and detail of what human skin is supposed to look like."[102] It is photorealism in human characters that has recently attracted the attention (and scorn in some cases) of audiences, scholars, and critics because it remains an elusive goal. Although films like *Toy Story* and *A Bug's Life* do not attempt to portray insects, animals, or humans as they appear in real life, they still try to simulate behaviors like gestures and facial expressions, as well as the underlying physiological apparatus that these gestures are based upon, as realistically as possible. One designer explains that, "recently, the development of more and more accurate simulation of human characters based on their anatomy has led to anatomically based modeling as the bottom-up approach for building characters from bones, muscles and skin."[103] Critics commonly fawned over these "surreal characters" in *A Bug's Life*. One critic admiringly comments that, "characters in *A Bug's Life* are capable of 3,900 possible movements, making them extraordinarily life-like. While no one would ever believe they're real, Woody and Buzz, Mr. Potato Head and Bo Peep have subtle texture and detail

[101] Chris Maraffi, *Maya Character Creation: Modeling and Animation Controls* (Indianapolis: New Riders Publishing, 2004), p. 11.
[102] George Borshukov, and J.P. Lewis, "Realistic Human Face Rendering for *the Matrix Reloaded*" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, San Diego, California, 2003), George Borshukov, Dan Piponi, Oystein Larsen, J.P. Lewis, and Christina Tempelaar-Lietz, "Universal Capture: Image-Based Facial Animation for *the Matrix Reloaded*" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, San Diego, California, 2003).
[103] Jorg Haber, Kolja Kahler, Hans-Peter Seidel, "Geometry-Based Muscle Modeling for Facial Animation" (paper presented at the Graphics Interface 2001, Ottawa, Ontario, 7-9 Jun 2001), p. 37.

unlike anything that exists in a cartoon."[104] The extraordinary elasticity, fullness, and surface texture of these models are characteristics of photorealism. As I will discuss in Chapter 4, critics are sometimes stringent in their assessment of the success of these attempts to portray the human form photorealistically.

Some research within the computer graphics field is also devoted to the second type of realism, referred to as non-photorealism. Non-photorealistic realism attempts to emulate 'painterly' qualities of artistic brush strokes, rather than represent natural phenomena as accurately as possible.[105]

> While traditional graphics techniques provide for the realistic display of three-dimensional objects, these methods often lack the flexibility to emulate expressive effects found in the works of artist's such as Michaelangelo and Cezanne. We introduce a technique for capturing custom artistic shading models from sampled art work. Our goal is to allow users to easily generate shading models which give the impression of light, depth, and material properties as accomplished by artists.[106]

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[104] David Kaplan, "High Tech in Toon Town: Why the Computer-Generated Hit *Toy Story* May Change the Business of Animation Forever," *Newsweek*, December 4 1995, p. 54.

[105] Hong Chen, et al., "Example-Based Composite Sketching of Human Portraits" (paper presented at the 3rd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2004), Stephen Chenney, et al., "Simulating Cartoon Style Animation" (paper presented at the 2nd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2002), Bruce Gooch, Greg Coombe, and Peter Shirley, "Artistic Vision: Painterly Rendering Using Computer Vision Techniques" (paper presented at the Non-Photorealistic Animation and Rendering, Annecy, France, 2002), Nick Halper, Stefan Schlechtweg, and Thomas Strothotte, "Creating Non-Photorealistic Images the Designer's Way" (paper presented at the 2nd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2002), James Hays, and Irfan Essa, "Image and Video Based Painterly Animation" (paper presented at the 3rd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2004), Christopher G. Healey, et al., "Perceptually Based Brush Strokes for Nonphotorealistic Visualization," *ACM Transactions on Graphics* 23, no. 1 (2004), Aaron Hertzmann, "Fast Paint Texture " (paper presented at the 2nd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2002), Matthew Kaplan, and Elaine Cohen, "Computer Generated Celtic Design" (paper presented at the 14th Eurographics Workshop on Rendering, Leuven, Belgium, 2003), Theresa Rhyne, et al., "Realism, Expressionism, and Abstraction: Applying Art Techniques to Visualization" (paper presented at the Conference on Visualization 01, San Diego, CA, 2001), Andrew Selle, Alex Mohr, and Stephen Chenney, "Cartoon Rendering of Smoke Animations" (paper presented at the Proceedings of the 3rd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2004), Brett Wilson, and Kwan-Liu Ma, "Rendering Complexity in Computer-Generated Pen-and-Ink Illustrations" (paper presented at the 3rd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France, 2004).

[106] Amy Gooch, Bruce Gooch, William Martin, and Peter-Pike J. Sloan, "The Lit Sphere: A Model for Capturing Npr Shading from Art" (paper presented at the Graphics Interface, Ottawa, Ontario, June 7-9 2001), p. 143.

The goals of photorealism and non-photorealism are similar in that both types of representation seek to simulate the real textures of the world, whether those textures are the pores on a human face, or the viscosity of oil paints. The idea, as with all animation interfaces, is to afford the user three dimensional interaction with objects and substances in a two-dimensional space (i.e., the screen). This emphasis on surface texture is clear in the claim that even non-photorealistic rendering techniques seek to establish "the look and feel of a work of art."[107]

Now that I have explained the types of digital representation in the computer graphics industry, and explained their singular, seemingly monomaniacal commitment to realism, I will summarize the historical development of the goals and techniques of realism. What many may not realize is that contemporary digital representation owes its breathtaking cinematic appeal to the traditional special effects industry and to early experimentation within the field of computer graphics.

Traditional filmic special effects have long been dedicated to realism. However, conventional special effects designers work with a different kind of material recalcitrance: real fabrics, plastics, latex, and a myriad of other materials. Stop-motion is probably the most well known technique for animating 3D characters prior to digital technology. "This is a traditional animation technique that manually positions an object slightly differently at each successive frame of exposure on film or video."[108] Stop-motion was used extensively in films like *Jason and the Argonauts* and *Clash of the Titans.* However, it is still a beloved cinematic style today and has been used in more recent films like *The Nightmare Before Christmas* and *James and the Giant Peach.* Like digital animators, conventional techniques are driven by an obsessive attention to the textures of the world. Digital animation follows this tradition of manipulating

[107] Ibid., p. 143.
[108] Masson, *CG 101: A Computer Graphics Industry Reference*, p. 124.

objects to create plausible imitations of transformations, explosions, and other special effects stunts. Prior to digital techniques, producers worked (and struggled) with models, puppets, animatronics, and clay to make models of spaceships and mythological creatures. Some classic fantasy and science fiction films portrayed organic movement in manually-fashioned scenes, objects, and characters. Some examples of these films include *The Dark Crystal, Labyrinth,* and *Star Wars*. Not surprisingly, the films that make history as watershed moments in special effects are those that deliver a believable world in full dimensionality. However, the perception of what appears realistic to audiences is historically contextual since obviously both the technologies and standards of realism are constantly changing and after the first blush, audience savvy easily keeps pace with each new technique. In keeping with traditional film conventions, the goal is to create the illusion of a seamless reality whereby the work of human hands remains invisible. For instance, George Lucas and his team produced the illusion of movement in *Star Wars* by creating spaceship travel through innovative camera techniques instead of using clunky and awkward models that tended to pierce the veil of illusion. *Star Wars* was the first film to use stationary models and a moving camera to create deep space realism.

Almost overnight, the use of digital animation and digital special effects in film is no longer a novelty. Although computer graphics had been used amply in scientific contexts, 1991 was the year that computer graphics broke into the entertainment industry with such films as *Jurassic Park* and *Toy Story.* Other recent cinematic milestones in digital design include: *The Abyss, Terminator 2: Judgment Day, Titanic, The Mummy, Monsters, Inc., Harry Potter, Gladiator,* and *Moulin Rouge.*[109] There had been earlier attempts to integrate computer graphics into films like *Tron*, but few were speculating that digital technology would replace conventional techniques at that time. One animation expert posits that "films are increasingly going digital for

[109] Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 4.

two main reasons. The first is that, in many cases, it is cheaper to create a virtual set in a computer than to build and shoot one on a live set . . . The second reason why films are increasingly going digital is the control it gives filmmakers."[110]

In 1991 *Jurassic Park* seemingly dealt a death blow to practitioners of conventional special effects. Industrial Light and Magic (ILM) originally planned to use stop-motion technology and models to create the dinosaurs for the film. Nevertheless, they were stunned to find that the CG models looked much better. Phil Tippet, expert in the field of stop-motion and go-motion photography (E.T.) lamented that "This was obviously a tremendous blow to the stop-motion animators . . . as it [CG] progressed to the point where the CGI dinosaurs looked better than go-motion dinosaurs, it was a different story . . . When it was demonstrated that on a photographic and kinetic level that this technology could work, I felt like my world had disintegrated."[111] However, Tippett's skills nonetheless remained in demand since, in order to create realistic movement ILM needed 'real' models to base their graphics on. Tippett and his crew used model dinosaurs to create "Dinosaur Input Devices." The models were needed so that their movements could be tracked via motion sensors and stored in a computer in order to generate a digital version. This technique is called "go-motion" and, although not strictly a computer graphics stunt, it is a "computer-controlled playback of stop-motion animation" which creates more realistic movements than traditional stop-motion.[112]

The use of motion capture software on real dinosaur models set a precedent for the integration of digital realism in film. Real models and human actors are used in films like *The Matrix, Final Fantasy*, and *The Lord of the Rings*, but their movements are tracked through

[110] Ibid., p. 5.
[111] Daniel Sevo, *History of Computer Graphics* [website] (Sevo, Daniel, March 25 2005 [cited March 31 2005]); available from www.danielsevo.com.
[112] Masson, *CG 101: A Computer Graphics Industry Reference*, p. 113.

software that feeds the details of movement into a computer in order to create their 3D doppelganger. Motion capture technology "refers to precisely recording the position and movement of an actor so you can later apply that motion to a digital figure's skeleton."[113] Later, I will treat the particular ideologies of motion capture in the film *Final Fantasy*, since critics were crestfallen when they discovered that the stunning digital animation in that film was done primarily through motion capture. Motion capture provides a much needed detour around the problem of building models and characters from the ground up in virtual space, which is rarely done. As I will show in Chapter 3, some (non-animators) consider this technique of creating digital realism a type of "cheating." However, as a check to hype and hubris, it is important to note that the digital effects industry is not poised to replace real actors and models altogether, rather it largely depends on real phenomena and humans, as well as conventional film techniques to find realistic and efficient ways to model digital characters, objects, and scenes.

What digital code and computer programming would do for the special effects industry is provide a potential tool for unlocking the "life essence" that lay dormant in matter. The recalcitrance of real-world materials and the methods of filming them is an ongoing source of frustration for filmmakers. It is not surprising that this obsession with fidelity continues in the computer graphics industry. Compared with models and cinematic techniques, digital animation provides a way of producing physiological realism in fantastic creatures because, in part, it focuses on recreating the underlying laws of physics or 'kinetics' that govern movement mathematically, rather than materially. For instance, George Lucas and ILM adopted digital effects with alacrity for the second *Star Wars* trilogy since, for Lucas, digital technology allowed him to create the "real world feel" he longed for in the original *Star Wars* trilogy beginning in

[113] Ibid., p. 118.

1977, without having to struggle with "popsicle sticks and scotch tape."[114] Lucas explained in an early interview (1977) that, "the success of the imaginary—it's to make something totally fabricated seem real . . . You have to find the material texture of the world: objects, fabrics, vehicles, tools. And if you make a mistake about an object or fabric, it'll betray you."[115] Although he does not clarify what he means by the ominous term "betray," it is clear that materials used to make models are unwieldy in the sense that their original purpose must be disguised. Lucas' ships were actually assembled using pieces of airplane models. The betrayal, therefore, occurs when clay looks like clay rather than a character or plastic looks like plastic instead of the metallic surfaces of space vessels and therefore, punctures the illusion of reality. In fact, Lucas echoes the concerns of contemporary digital animators when he states "I need to keep a 'centered' view concentric with the universe I'm constructing, so at every moment I maintain a general view of a multi-layered reality."[116]

Nevertheless, introducing the new tool of the computer and leaving behind the dead weight of mannequins and models has not necessarily simplified the practice of special effects by eliminating excess matter nor has it lead to the total abandonment of makeup, costumes, and elaborate set designs. Although Lucas would agree that virtual reality has granted him a means of making creatures, ships, and scenes, as well as special effects and organic movement, that would have been nearly impossible otherwise, it is clear that this new technology created as many problems for him as it solved. In 1999, Lucas beamed to an interviewer from *Wired* Magazine saying, "I am finally free to tell the kinds of stories I want to tell."[117] In 2002 however, he

[114] Mark Hamill interview in "Star Wars Trilogy: Special Edition," ed. George Lucas (1997).
[115] Claire Clouzot, *George Lucas: Interviews*, ed. Sally Kline (Jackson: University Press of Mississippi, 1999), p. 59.
[116] Ibid., p. 58.
[117] Paula Parisi, "Grand Illusion: The Master of Myth Rewrites History," *Wired*, May 1999, p. 1.

admitted that "*The Phantom Menace* (1999) wasn't the exciting action movie the fans wanted me to make. They wanted to see *The Matrix.*"[118]

Films keen on product placement and spin-offs, or realistic mise-en-scene still rely heavily on set and costume design. A good example of this is Peter Jackson's *Lord of the Rings* trilogy, in which Weta Digital, of New Zealand labored like old-world artisans to make the signature LOTR jewelry, weapons, furniture, and costumes (much of which can now be purchased as 'official' LOTR merchandise).[119]

The really dazzling revolution in computer graphics is achieved via the technique of rendering through which the computer adds surface textures and light effects to a 3D model. Within the field of computer graphics, rendering has two meanings. The first is literal. Professional animator Adam Watkins provides a good explanation of rendering in the following passage:

> When your computer renders, it essentially takes colored bits of information and arranges them so that the whole looks like a cohesive image. As seen earlier, figures are comprised of small pixels that can be thought of as tiles. In this way, bitmapped figures are a bit like Byzantine mosaics. The computer is the artisan placing mosaic tiles together to make the image you created . . . The larger the tiles, the faster your artisan computer can fill in the spaces.[120]

Rendering refers to a technical process whereby the computer draws an image by translating human parameters. Rendering is the process of generating an image from a description of three dimensional objects, by means of a software program. Essentially, it is a command that tells the computer to "draw."

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[118] Jeffrey Wells, "The Matrix Sequels," *Rolling Stone*, Oct. 3 2002, p. 1.
[119] Audrey Doyle, "Two Towers: Weta Adds Crowds and Characters to the Second Lord of the Rings Movie," *Computer Graphics World* 2003, p. 28.
[120] Watkins, *3d Animation: From Models to Movies*, p. 267.

The second definition of rendering is shorthand to refer to realism. In this sense, rendering describes the overall process of adding surface attributes and lighting effects to the surface of an object. Pejoratively, rendering refers to "adding textures" such as fur, hair, pores, and other surface irregularities. The changing meaning of rendering within the computer graphics field is a result of more and more complex algorithms that are written by software designers and are worked into interfaces used for digital animation. It is often referred to in general as polishing, refining, or adding textures and lights. One early example of using rendering to create realistic texture and depth, specifically to mimic the "gold glaze a painter might use," is featured in Disney's *Beauty and the Beast* ballroom scene. "Much of that rich visual detail was achieved through rendering rather than modeling—through the use of textures rather than geometry to create patterns and simulate structure"[121] This scene also depicted one of the first uses of the celebrated "virtual camera" effect, made famous for its use several years later in *The Matrix*. This technique creates the illusion that a camera is swirling 360 degrees around the characters as they dance in a giant 3D ballroom.

Rendering is a computationally "expensive" or time-consuming process. The goals of realism are determined by the power and speed of the machinery that 'draws' the objects modeled in virtual space by the animator. Rendering is the culmination of a series of laborious steps. A great deal of research is devoted to improving computer speed since rendering depends on the "engine" that processes information rich files and makes 3D images possible.[122]

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[121] Barbara Robertson, "Beauty and the Beast: 3d Graphics Technology Plays a Growing If Subtle Role in Disney's Newest 2d Animation," *Computer Graphics World*, Dec. 1991, p. 44.

[122] Reuven Bar-Yehuda, and Craig Gotsman, "Time/Space Tradeoffs for Polygon Mesh Rendering," *ACM Transactions on Graphics* 15, no. 2 (1996), Enrico Gobbetti, and Eric Bouvier, "Time-Critical Multiresolution Scene Rendering" (paper presented at the Conference on Visualization 99: Celebrating Ten Years, San Francisco, CA, 1999), Rich Gossweiler, "A System for Application-Independent Time-Critical Rendering" (paper presented at the Conference on Human Factors in Computing, Denver, CO, 1995), James T. Klosowski, and Claudio T. Silva, "Rendering on a Budget: A Framework for Time-Critical Rendering" (paper presented at the Conference on Visualization 99: Celebrating Ten Years, San Francisco, CA, 1999), Guenter Knittel, "High-Speed Volume

Advancement in image quality is dependent upon the speed with which the computer can process the large amounts of data contained in the files. Without adequate computer power, rendering a scene, object, or character might take days to complete. One handbook for digital animation encourages the user to be patient with this time consuming process. "When you find yourself glaring into your monitor, inches from the screen, take solace in the fact that the computer is being pushed to its limits by the rendering engine, and while it may look like nothing is happening, the machine is hard at work painting your digital masterpiece."[123]

The computer graphics industry's quest for realism was stalled by the simple fact that computers were not powerful enough to render animated frames. The importance of rendering time is demonstrated by practitioners who compare the relative speed of old and new systems. "We did a rough calculation, and the rendering time of all the digital characters [in *The Two Towers*] was about 460 years if rendered on a home PC."[124] David Em, animator, artist, and reviewer of SIGGRAPH conferences, claims, "some of my recent test frames of Maya 5 on our Compaq w8000 dual 2.8 GHz Xeon system have taken over twelve hours to render. At 24 frames per second, a ninety minute film would take a couple hundred years to generate."[125] Technologies like graphics cards and RenderMan software speed up the process. "RenderMan is a standardized interface specification for sending modeling and animation data to a rendering

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Rendering Using Redundant Block Compression" (paper presented at the 6th Conference on Visualization 95, 1995), Xinyue Li, and Han-Wei Shen, "Time-Critical Multiresolution Volume Rendering Using 3d Texture Mapping Hardware" (paper presented at the Symposium on Volume Visualization, Boston, MA, 2002), Steven Molnar, John Eyles, and John Poulton, "Pixelflow: High-Speed Rendering Using Image Composition," *ACM SIGGRAPH Computer Graphics, Proceedings of the 19th annual conference on Computer graphics and interactive techniques SIGGRAPH '92* 26, no. 2 (1992), Jurriaan D. Mulder, and Robert van Liere, "Fast Perception-Based Depth of Field Rendering" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Seoul, Korea, 2000), Claudio Silva, Joseph S. B. Mitchell, and Arie E. Kaufman, "Fast Rendering of Irregular Grids" (paper presented at the Symposium on Volume Visualization, San Francisco, CA, 1996), Nicolaas Tack, Francisco Moran, Gauthier Lafruit, and Rudy Lauwereins, "3d Graphics Rendering Time Modeling and Control of Mobile Terminals" (paper presented at the 9th International Conference on 3D Web Technology, Monteray, CA, 2004).

[123] Jeff Paries, *The Animation Master 2000 Handbook* (Rockland, MA: Charles River Media, Inc., 2000), p. 574.

[124] Doyle, "Two Towers: Weta Adds Crowds and Characters to the Second Lord of the Rings Movie," p. 28.

[125] David Em, "Siggraph 2003," in *Byte.com* (CMP Media LLC, 2003).

system."[126] This image synthesis software system is widely used in film effects and animation today. In keeping with the treatment of virtual objects as if they are materially real, the term "heavy" is used to describe 3D objects that are slow to render because they contain a lot of information. As a result, rendering methods work hand-in-hand with modeling techniques that focus on the surface of an object instead of its weighty interior.

Since the relationship between computer power and realism is a symbiotic one, innovations in shortcuts drive the computer graphics industry in both the rendering phase and the modeling phase. Pixar invented the "Render Farm" in 1997 and it is now a much-used tool in the computer graphics industry. "Complex computer animation, like that in the Pixar/Disney film *Toy Story*, required so many powerful Sun Inc. computers linked together that it was referred to as a "farm" of Sun computers. These machines did the equivalent of about thirty-six years of man hours of computing time."[127] The problem of harnessing enough computer power to render complex scenes continues into the present day since developments in animation software lead to a demand for more capable hardware.

Strategies for reducing rendering time over the past 5 years have been extraordinarily successful and are, in part, responsible for the proliferation of digitized scenes and special effects in television and film today. "Plug-ins" like video cards speed up the rendering process and allow the animator to view their work incrementally in real time—rather than waiting until the very end of character modeling, rigging, and scene design to see if they made a mistake. This valuable time-saving device was displayed at the 1999 SIGGRAPH Convention. Em and Pournelle describe Maya's new proprietary photorealistic renderer, "which lets you preview your scenes before committing to time and resource-intensive final animation renders. This is

[126] Masson, *CG 101: A Computer Graphics Industry Reference*, p. 160.
[127] Kenneth R. O'Connell, "The Art of Computer Animation," *School Arts*, Nov. 1997, p. 36.

powerful stuff that makes important progress in moving 3D software up from the middle ring of hell, where it currently resides, up to the lower rings of heaven, where it rightfully belongs."[128] This passage underscores the persistent problem of designing animation software that is easy to use and accessible to relative beginners. Aspiring animators, professionals, designers, and end-users alike, are placing greater demands on the power and speed of their machinery, as well as on ease of access. Even the average Internet surfer is impatient with the capabilities of the technological engine, always wanting to speed up the temporal process to the point of achieving instantaneous results. In short, the computer graphics industry is absolutely dependent on innovations in computer engineering. Again, the obsession with realism creates a mutually-dependent relationship between hardware and software. Software design for computer graphics is driven by a need for short-cuts around the problem of processing power. Nevertheless, even when processing power is available through rendering farms (groups of computers), graphics cards, and stronger computers, animators are seldom satisfied with the level of realism that this interdependent relationship affords.

Despite advancements in software and hardware, the rendering process, like character modeling, remains a painstaking one. Avgerakis explains a typical process as "model, texture, render, retexture, rerender, sometimes remodel, rerender, retexture, rerender—you get the idea."[129] Complex digital scenes usually require that the work progress in layers or through a series of repeated steps that take a considerable amount of computer processing power and time.

> Animation, particularly the modeling phase, is a kind of iterative process. This means that you tend to perform a step, evaluate it, and then reiterate the process to a finer level of detail and/or satisfaction. When satisfied, the animator will proceed to the next

[128] David Em and Alex Pournelle, "The Siggraph and Seybold Report," review of Reviewed Item, *Byte.com*, no. (1999).
[129] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 178.

> task in a methodical progression. In the process of modeling an object, you might execute hundreds, perhaps thousands of iterations.[130]

Digital texts are usually completed in a series of layers and each of these layers is rendered separately. Therefore, in a film like the *Matrix*, characters, objects, scenes, and special effects are rendered separately. Character actions are based on the movements of real humans (the actors), while other scenes are completely fabricated in virtual space like the huge cavernous interior of the home base Zion in *The Matrix Revolutions.* But even something as simple as a floating fetus in the first *Matrix* installment is described in magazines like *Computer Graphics World* as involving a number of complex layers to create the illusion of realism. For instance, first they modeled and rendered the fetus itself, then the pod in which the fetus is encased. But this pod itself is comprised of three more layers, all rendered separately, a mucus layer, a fluid layer, and the membrane wall. Rendering objects in layers furthers the goal of realism because through this technique, designers can pay special attention to the texture of surfaces. On large projects like *Shrek* or *Final Fantasy* there are separate teams of animators responsible for each phase.

Animators and technology buffs are often impressed by how many layers it takes to complete a particular digital text. In fact, the number of layers it took to complete a particular object determines a designer's bragging rights. More layers mean more applause and approval from the community. The completion of the animated short of a comical cowboy (the convention took place in Texas) to launch the 2002 SIGGRAPH Convention took 30 to 40 layers of imagery. "Each layer enables other layers to be superimposed so that various elements can be aligned with one another. At some point, you may save all the layers separately to form a file

[130] Ibid., p. 179.

collection that represents the entire object, or you may combine any two or more layers to combine all the elements together into one object."[131]

We find two incongruous attitudes at work within the industry. On the one hand, speed and power of the machinery is prized for its own sake as well as for its utilitarian purposes. Yet, feeling the need for speed is relative to the goal of realism, which is never adequately reached in the minds of most end-users, designers, and producers. Therefore, as computer speed and power increases, so does the complexity of digital animation. Now that animators have the power to render complex scenes, they routinely create more labor for themselves through the desire for more organically sophisticated models. In the end, the process remains consistent with the twin goals of speed and complexity so that the time won through powerful computers is lost in the effort to produce greater levels of realism.

Most innovations in rendering photorealistic images revolve around light effects that are added during the rendering process. Unfortunately, creating light and texture algorithms is even more challenging than modeling from polygons and collections of triangles. On a basic level, you would not be able to see textures such as tiny bumps without some light source focusing on the object and creating small shadows between the bumps. Collectively, all algorithms written to render light effects fall under the industry category of 'global illumination.' Global illumination techniques are those programs that attempt to simulate the various ways in which light tends to bounce around for a while before it fades out, rather than coming directly from a light source like the sun. In other words, a large amount of the light found in the natural world is actually recycled light—reflected, refracted, or absorbed. The way in which light plays upon surfaces is a tremendous factor in how we view the natural world and of course, an understanding of lighting effects (in terms of its artificial recreation) borrows from conventional filmic techniques.

[131] Ibid., p. 179.

"Lighting is one of the most complicated of all computer graphics algorithms, and it is also one of the most critical for believable images . . . The basis of most lighting approximation techniques is in estimating the amount of light energy being transmitted, reflected, or absorbed on a given point on a surface."[132] The following sections describe effects produced by rendering algorithms over the past 30 years.

Again, there are hundreds of articles within the SIGGRAPH archives that are dedicated to lighting techniques alone. The first attempt to write code for rendering light effects dealt with the problem of "shading."[133] Shading refers to the process of making colors and brightness levels vary with different intensities of light. A thorough understanding of human perception of the light spectrum is essential to producing realistic effects. "Gouraud shading," named after its inventor, is "used to achieve smooth lighting on low-polygon count surfaces without the heavy computational requirements of calculating lighting for each pixel."[134] However, the effect of Gouraud shading is sometimes a too-smooth-looking surface. In fact, the movement from shiny surfaces to those that depict natural imperfections is largely due to innovations in light effects, in addition to modeling techniques. In 1975, Bui Tuong Phong described a rendering algorithm that

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[132] Carlson, *A Critical History of Computer Graphics and Animation* .

[133] Gregory D. Abram, and Turner Whitted, "Building Block Shaders" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Dallas, TX, 1990), Tomas Akenine-Moller, and Ulf Assarsson, "Approximate Soft Shadwos on Arbitrary Surfaces Using Penumbra Wedges" (paper presented at the 13th Eurographics Workshop on Rendering, Pisa, Italy, 2002), Robert L. Cook, "Shade Trees," *ACM SIGGRAPH Computer Graphics, Proceedings of the 11th annual conference on Computer graphics and interactive techniques SIGGRAPH '84* 18, no. 3 (1984), Michael F. Deering, and Scott R. Nelson, "Leo: A System for Cost Effective 3d Shaded Graphics," *Proceedings of the 20th annual conference on Computer graphics and interactive techniques* 43, no. 2 (1993), Pat Hanrahan, and Jim Lawson, "A Language for Shading and Lighting Calculations" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Dallas, TX, 1990), Michael McCool, Zheng Qin, and Tiberius Popa, "Shader Metaprogramming" (paper presented at the Workshop on Graphics Hardware, ACM SIGGRAPH/EUROGRAPHICS Conference on Graphics Hardware, Saarbrucken, Germany, 2002), Marc Olano, and Anselmo Lastra, "A Shading Language on Graphics Hardware: The Pixelflow Shading System" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1998), Randy Scoggins, Raghu Machiraju, and Robert J. Moorhead, "Approximate Shading for the Re-Illumination of Synthetic Images" (paper presented at the Conference on Visualization 01, San Diego, CA, 2001), Turner Whitted, "An Improved Illumination Model for Shaded Display," *Communications of the ACM* 23, no. 6 (1980).

[134] Henri Gouraud, "Continuous Shading of Curved Surfaces," *IEEE Transactions on Computers* 20, no. 6 (1971), pp. 623-628.

communicated the parameters of human visual perception more accurately to the computer (devises a way of computing those parameters). He explained that

> The quality of computer generated images of three-dimensional scenes depends on the shading techniques used to paint the objects on the cathode-ray tube screen . . . The various methods of object modeling, shading, and hidden surface removal are thus strongly interconnected . . . Human visual perception and the fundamental laws of optics are considered in the development of shading rule that provides better quality and increased realism in generated images.

Phong shading introduced shiny highlights to plastic surfaces, whereas Gouraud shading simply offered smooth surfaces without realistic light reflection. Both, however, are partly responsible for the smooth and shiny style of digital animation projects produced in the early 1980s. It wasn't until James Blinn's and Lance Williams' landmark innovations, "Simulation of Wrinkled Surfaces" and "Casting Curved Shadows on Curved Surfaces," that new ways of creating lighting effects to increase the realism of digital representations were introduced. Williams argues that,

> Computer generated shaded images have reached an impressive degree of realism with the current state of the art. They are not so realistic, however, that they would fool many people into believing that they are real. One problem is that the surfaces tend to look artificial due to their extreme smoothness. What is needed is a means of simulating surface irregularities that are on real surfaces to index into a texture definition function which scales the intensity of reflected light . . . This paper presents a method of using texturing function to perform a small perturbation on the direction of the surface normal before using it in the intensity calculations. This process yields images with realistic looking surface wrinkles without the need to model each wrinkle as a separate surface element.[135]

[135] James Blinn, "Models of Light Reflection for Computer Graphics and Interactive Techniques" (paper presented at the 4th Annual Conference on Computer Graphics and Interactive Techniques, San Jose, CA, July 1977), James Blinn, "Simulation of Wrinkled Surfaces" (paper presented at the 5th Annual Conference on Computer Graphics and Interactive Techniques, August 1978), Lance Williams, "Casting Curved Shadows on Curved Surfaces" (paper presented at the 5th Annual Conference on Computer Graphics and Interactive Techniques, August 1978), p. 23.

Although created in the mid 1970s, these techniques would become standard ways to render surfaces and light effects in industry practice.

Other important techniques for rendering light effects include ray tracing and photon mapping.[136] Watkins provides a lucid explication of the complex technique of ray tracing that includes the traditional artistic convention of perspective. He states that

> An important idea behind perspective is that every shape and object depicted on the projection plane sends a 'ray' to the viewport [box or animation workspace on the computer screen], or our eye . . . Imagine that all objects in a scene emit these theoretical 'rays.' On their way to the viewport, they will pass through the projection plane that, in the case of computers, is the screen. In theory, the screen records what shade, hue, and intensity the pixels on your monitor will appear. Ray tracing works backwards by working down these 'rays' to the objects.[137]

According to Turner Whitted, ray tracing is "is one of the most popular methods used in 3D computer graphics to render an image. It works by tracing a path taken by a ray of light through the scene, and calculating reflection, refraction, or absorption on the ray whenever it intersects an object (or the background) in the scene."[138] Ray tracing allows the rendering of shadows and

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[136] John Amanatides, "Ray Tracing with Cones," *ACM SIGGRAPH Computer Graphics, Proceedings of the 11th annual conference on Computer graphics and interactive techniques SIGGRAPH '84* 18, no. 3 (1984), Alan H. Barr, "Ray Tracing Deformed Surfaces" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1986), Nathan A. Carr, and Jesse D. Hall, "The Ray Engine" (paper presented at the SIGGRAPH/EUROGRAPHICS Workshop on Graphics Hardware, Saarbrucken, Germany, 2002), Robert L Cook, Thomas Porter, and Loren Carpenter, "Distributed Ray Tracing," *ACM SIGGRAPH Computer Graphics, Proceedings of the 11th annual conference on Computer graphics and interactive techniques SIGGRAPH '84* 18, no. 3 (1984), Robert A. Cross, "Interactive Realism for Visualization Using Ray Tracing" (paper presented at the IEEE Visualization, Atlanta, GA, 1995), Paul S Herckbert, "Ray Tracing Jell-O Brand Gelatin," *Communications of the ACM* 31, no. 2 (1988), James T. Kajiya, "Ray Tracing Volume Densities," *ACM SIGGRAPH Computer Graphics, Proceedings of the 11th annual conference on Computer graphics and interactive techniques SIGGRAPH '84* 18, no. 3 (1984), Timothy L. Kay, "Ray Tracing Complex Scenes," *ACM SIGGRAPH Computer Graphics, Proceedings of the 13th annual conference on Computer graphics and interactive techniques SIGGRAPH '86* 20, no. 4 (1986), Marc Levoy, "Efficient Ray Tracing of Volume Data," *ACM Transactions on Graphics (TOG)* 9, no. 3 (1990), Steven Parker, et al., "Interactive Ray Tracing " (paper presented at the Symposium on Interactive 3D Graphics, Atlanta, GA, 1999), Timothy J. Purcell, et al., "Ray Tracing on Programmable Graphics Hardware" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, San Antonio, TX, 2002), Ingo Wald, et al., "Interactive Global Illumination Using Fast Ray Tracing" (paper presented at the Eurographics Workshop on Rendering, Pisa, Italy, 2002).

[137] Watkins, *3d Animation: From Models to Movies*, p. 12.

[138] Whitted, "An Improved Illumination Model for Shaded Display," p. 343.

other effects with relative ease. The drawback however, is that early ray tracing took a long time to render. Photon mapping, however, simulates the way in which light interacts with other objects.[139] "Specifically, it is capable of simulating the refraction of light through a transparent substance, such as a glass of water . . . and some of the effects caused by particulate matter such as smoke or water vapor."[140] Another landmark project explains that

> Current light reflection models used in computer graphics do not account for the object-to-object reflection between diffuse surfaces, and thus incorrectly compute the global illumination effects. The new procedure, based on methods used in thermal engineering, includes the effects of diffuse light sources of a finite area, as well as the "color-bleeding" effect which are caused by the diffuse reflections.[141]

This technique is also referred to as radiosity, which is celebrated as an important breakthrough in rendering light since "the inclusion of radiosity calculations in the rendering process often lends an added element of realism to the finished scene, because of the way it mimics real-world phenomena."[142] For example, if one were to design a red ball sitting on a white floor, the red ball would create a subtle hue which would likewise be reflected on the floor.[143]

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[139] Mike Cammarano, and Henrik Wann Jensen, "Time Dependent Photon Mapping" (paper presented at the 13th Eurographics Workshop on Rendering, Pisa, Italy, 2002), Kirill Dmitriev, Stefan Brabee, Karol Myszkowski, and Hans-Peter Seidel, "Interactive Global Illumination Using Selective Photon Tracing" (paper presented at the 13th Eurographics Workshop on Rendering, Pisa, Italy, 2002), Timothy J. Purcell, Craig Donner, Mike Cammarano, Henrik Wann Jensen, and Pat Hanrahan, "Photon Mapping on Programmable Graphics Hardware" (paper presented at the SIGGRAPH/EUROGRAPHICS Workshop on Graphics Hardware, San Diego, CA, 2003), Tin-Tin Yu, John Lowther, and Ching-Kuang Shene, "Photon Mapping Made Easy" (paper presented at the Technical Symposium on Computer Science Education, St. Louis, MO, 2005).

[140] Whitted, "An Improved Illumination Model for Shaded Display," p. 343.

[141] Cindy M. Goral, Kenneth E. Torrance, Donald P. Greenberg, Bennett Battaile, "Modeling the Interaction of Light between Diffuse Surfaces" (paper presented at the 11th Annual Conference on Computer Graphics and Interactive Techniques, January 1984), p. 213.

[142] Ibid., p. 213.

[143] Hong Chen, and En-Hua Wu, "An Efficient Radiosity Solution for Bump Texture Generation" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Dallas, TX, 1990), Michael Cohen, Shenchang Eric Chen, John R. Wallace, and Donald P. Greenberg, "A Progressive Refinement Approach to Fast Radiosity Image Generation," *ACM SIGGRAPH Computer Graphics, Proceedings of the 15th annual conference on Computer graphics and interactive techniques SIGGRAPH '88* 22, no. 4 (1988), Greg Coombe, Mark Harris, and Anselmo Lastra, "Radiosity on Graphics Hardware" (paper presented at the 2004 Conference on Graphics Interface, London, Ontarion, Canada, 2004), George Drettakis, Eric Paquette, and Pierre Poulin, "Surface Aging by Impacts" (paper presented at the Graphics Interface, Ottawa, Ontario, 7-9 June 2001), Chen-Chin Feng,

While current lighting effects have developed a mimetic capacity heretofore unknown, it is clear that the industry is not satisfied with the results. For instance, the makers of *Toy Story 2* deliberately exaggerate light effects in order to dazzle the audience and fellow animators with their new rendering methods. There is a point in the film when the characters walk into a toy store and their reflections are perfectly mirrored in the linoleum floor. However, these stunning effects do not copy 'reality' at all, but instead they represent light's potential properties. In other words, the character's reflections on the floor are too clear and contain the colorful hues of their clothing. In a live-action scene, as well as in the real-world, you might see a reflection in the floor but it will probably be colorless and blurry.[144] Production teams are endlessly struggling to create techniques that are wholly unique such as bullet time in *The Matrix,* which was immediately copied and lampooned in a variety of popular contexts including the film *Shrek.* In many ways the ruthless logic of novelty, the always new as precisely always the same, is what drives efforts to create more realistic digital representation. Within the computer graphics manuals, the success of a film such as *Toy Story* is partially assessed in terms of its novelty. Although it enjoys the honor of being the first full-feature, digitally-animated film, the techniques used to create it had already been used in the industry for a long time prior to its release as a form of entertainment.

How is the quest for realism instantiated in the design of digital animation? To answer this question, I begin with a discussion of the basis of all computer graphics—modeling. However, it is somewhat inaccurate to separate modeling and rendering, since they enjoy a

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and Shi-Nine Yang, "A Parallel Hierarchical Radiosity Algorithm for Complex Scenes" (paper presented at the Parallel Rendering Symposium, Phoenix, AZ, 1997), Alexander Keller, "Instant Radiosity," *ACM Transactions on Graphics* 14, no. 3 (1995), J. Richard, and J. P. Singh, "Parallel Hierarchical Computation of Specular Radiosity" (paper presented at the Parallel Rendering Symposium, Poenix, AZ, 1997), Frank Schoffel, "Online Radiosity in Interactive Virtual Reality Applications" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Lausanne, Switzerland, 1997).

[144] Compare store scenes in *Toy Story 2* to *One Hour Photo* for a good comparison of a "reflecting floor scene" in digital space and live-action space.

symbiotic relationship. Therefore, I will first describe what modeling is and talk about some of the important historical developments that shaped the computer graphics industry's standard of realism. Next, I will discuss the importance of computer power in rendering these models, ending with a section that describes the interconnectedness of these seemingly separate realms of human modeling and computer processing.

All types of computer graphics and digital animation must begin with a modeling phase. Digital animation is essentially a process of building, molding, manipulating, and setting into motion objects and characters in virtual space. Digital modeling has a closer familial tie to puppetry, sculpture, and set design, than with painting, photography, and film because digital media artifacts are usually treated as active organic processes by graphics practitioners. In fact, user manuals describe the process of "rigging" a character as if it were "much like that of building a marionette or puppet."[145] Even a relatively simple object like a cube must be considered from the point of view of surface, volume, weight, and light effects.

At the most basic level, modeling scenes and characters is based on simple polygons like cones, cubes, spheres, and other geometric shapes. In fact, a working knowledge of geometry is an essential skill for an aspiring animator. According to professional animator, George Avgerakis, within the virtual space of the computer "an object can refer to any point, collection of points, polygon, collection of polygons, surfaces, or effects . . . An orange, a wall, an ocean, a streak of light, a puff of smoke, or even an infinitesimal point that cannot be seen anywhere in the animation (called a *null object*). Cameras and lights sometimes act like objects too, because they can be animated in much the same way as an object."[146] Objects and operations can be manipulated by an operator because all digital objects are essentially mathematical or

[145] *Learning Maya 5: Character Rigging and Animation*, p. 14.
[146] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 175.

algorithmic representations as far as the computer is concerned. The computer treats them all the same way, whether that object is a ball, a ripple, or a flame. In the animators' practice, active organic processes are the same as inactive inanimate things.

It is safe to claim that digital representation today is more sophisticated than graphics in the 1980s and 1990s. But while the imagery alters perceptibly, the underlying law that governs computer graphics "progress" remains the same. The history of efforts to create more and more realistic computer imagery is punctuated by a series of shortcuts meant to skirt the shortcomings of either code writing or computer power. As the above section on rendering indicates, the development of computer programs and computer technology is driven by principles of speed. Traditionally, computer graphics are information intense representations that take a computer a long time to process. As a result, the history of the graphics industry is marked by a interdependent relationship between modeling techniques and computer speed since the limits of computer technology have a significant imact on the graphics field.

Watkins describes the process of building organic models from the ground up as a very difficult one that requires some "cheating." "Organic shapes are perhaps the most difficult of all to do in 3D. As free flowing as they seem to be, our eyes can always pick out when the seeming randomness of organic shapes just is not right . . . To combat this problem, one of the best methods is to steal directly from Mother Nature by scanning her natural textures and uses them to define geometry."[147] Even though the goal is to reproduce the appearance of natural phenomena, the process of designing these technologies of representation is completely artificial. For instance, an object like a metal ball may look solid and heavy, but in truth the code written to tell the computer what to draw, has only focused on the light dancing off the surface of the ball. Therefore, light effects help produce the illusion of a solid object. "The proof, as some maintain,

[147] Watkins, *3d Animation: From Models to Movies*, p. 154.

is in the believability of the image, not necessarily in the accuracy of the representation."[148] This explication of realism demonstrates that audience perception plays a crucial role in establishing the success of realism. At the very least, the surface attributes of the object must provide the illusion of a solid, three-dimensional object. According to the computer, however, the 'inside' of the object is empty.

Several important innovations in computer graphics are considered to be historical landmarks in the development of photorealistic models. Again, the computer graphics timeline is characterized by efforts to achieve greater levels of realism, while simultaneously skirting the problem of computer power deficiency. The story begins with the problems inherent to modeling three-dimensional objects in two-dimensional space. In simple terms, engineers began the design process with large, simple shapes. For instance, to model a character's head, you would "deform" it, or push, pull, and mold a simple sphere. Designers realized that using smaller and smaller polygons and sets of polygons allowed them to model finer details and textures. Further, the ability to work with lines or curves, granted even more flexibility to the modeling phase. Keep in mind however, that we are dealing with curved lines in three-dimensional space rather than "drawing" on a flat plane. Curved lines in 3D space amount to curved surfaces defined as "cages" that are considered "solid." Before I explain this process in greater detail, it is important to clarify that the historical development of modeling technology is pervaded by a constantly receding problem-solution rhythm. In other words, each solution creates more problems, ad infinitum.

The problem with creating realistic three-dimensional objects, in short, is that computers cannot draw curves. Computers are based on Cartesian geometry and, as a result, they draw lines from point-to-point, only bending gradually as they go. While advances in creating curved

[148] Carlson, *A Critical History of Computer Graphics and Animation*.

surfaces involve complex mathematical algorithms that I will not elaborate on here, overall these innovations used smaller and smaller sets or 'meshes' of polygons (usually triangles) while increasing the power of the machinery necessary to process more and more complex and information-rich data. Polygon modeling comprises the early history of 3D graphics. As the novelty of three-dimensional imagery wore off, however, a major limitation in this technique was discovered. The much coveted photo-realism was inhibited by the too smooth surfaces, stiff movement, and the block-like look of polygon based models.

> Computers do several things well, one of which is creating smooth, perfect surfaces . . . One of the new trends rapidly emerging in 3D is the challenge to find ways to make computer-generated imagery look not quite so computer generated. People are tired of the smooth surfaces and the easy-to-create reflections, and viewers long ago ceased to be impressed by the standard reflective metal surfaces. In order to make your work really stand out, an important key is to create imagery that is imperfect, dirty, and all-around scummy.[149]

Designers had to figure out how to introduce greater flexibility and textural attributes into their polygon models and, in turn, make this new flexibility accessible for end-users. The logical answer was to investigate ways of using curves. The use of Bezier surfaces, named after its original mathematician designer, would eventually lead to the ability to sculpt surfaces by using collections of tiny triangles.

Bezier patches allowed the representation of curved surfaces, yet the problem with this technique was that patches were difficult to render since they contained a lot of information and were awkward to work with.[150] Engineers figured out a way to make lines bend by unhinging them from their anchor points, thereby reducing their dependency on Cartesian coordinates in order to increase model flexibility. This was done by expressing lines via sophisticated

[149] Watkins, *3d Animation: From Models to Movies*, p. 184.
[150] Jean-Claude Duguet, "Scientific Apl2 Computing: Bezier, Bsplines, Nurbs (Curves & Surfaces)," *ACM SIGAPL APL* 32, no. 1 (2001).

algorithms versus geometric and spatial representation. "In this process, the designers realized that the computer used polygons to define specific sets of points in 3D space. If these points could be expressed instead by formulas, the resulting shape would be smoother, easier to calculate, and more flexible."[151] The result of this process was the invention of "splines" which is also a type of mathematically defined curve. "Splines are very different from triangles used in polygon modelers in that moving one spline is equivalent to moving dozens or even hundreds of polygons simultaneously. Spline models are also generally much lower in density than equivalent polygon models, making them easier to work with, and easy on storage space."[152] Spline modeling reduces the amount of points needed to define a curve and as a result, produces more subtle shapes and surfaces.[153]

The algorithms that have been transformed into digital animation interfaces like Maya and 3ds Max, were initially written by engineers. A landmark example of the coveted technique of sculptured surfaces occurred as early as 1974. The "Teapot Subdivision" project now enjoys the prestigious place in Boston's Museum of Computing History as "the first computer graphics object to be designed and rendered as a sculptured surface, rather than a set of polygons."[154] The problem with the teapot, however, was that it was "hollow" and this lack of substance is visible in the computer-generated image.

Splines create a grid or cage, and the polygons inside this cage are called meshes which can be twisted and manipulated unlike one large polygon. The drawback of spline modeling, however, is that splines cannot be cut and pasted and are limited in their flexibility as design

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[151] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 239.
[152] *Learning Maya 5: Character Rigging and Animation*, Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 41.
[153] Demetri Terzopoulos, and Quin Hong, "Dynamic Manipulation of Triangular B-Splines" (paper presented at the Symposium on Solid Modeling and Applications, Salt Lake City, UT, 1995).
[154] Carlson, *A Critical History of Computer Graphics and Animation*.

tools.[155] These lines, when unhinged from their anchor points on a Cartesian graph, will snap back into a straight line.

Designers crafted NURBS (non-uniform rational B-Splines) to solve this problem. These curves were more flexible because they could be divided, broken down into smaller parts, and moved around in virtual space.[156] Not surprisingly, designers ran into problems with NURBS as well. Because of the cut and paste mechanism, characters and objects, when animated, would split at the seams, creating black holes in the middle of an animated scene. Designers approached this problem with a technique that is widely used today, subdivision surfaces or patches.[157]

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[155] Reza Abedi, et al., "Spacetime Meshing with Adaptive Refinement and Coarsening" (paper presented at the Annual Symposium on Computational Geometry, Booklyn, NY, 2004), David C. Arney, and Joseph E. Flaherty, "An Adaptive Mesh-Moving and Local Refinement Method for Time-Dependent Partial Differential Equations," *Mathematical Software* 16, no. 1 (1990), Paul L. Chew, "Guaranteed-Quality Mesh Generation for Curved Surfaces" (paper presented at the Annual Symposium on Computational Geometry, San Diego, CA, 1993), Ilja Friedel, Peter Schroder, and Andrei Khodakovsky, "Variational Normal Meshes," *ACM Transactions on Graphics (TOG)* 23, no. 4 (2004), Hanrahan, "A Language for Shading and Lighting Calculations," Takeo Igarashi, and John F. Hughes, "Smooth Meshes for Sketch-Based Freeform Modeling" (paper presented at the Symposium on Interactive 3D Graphics, Monteray, CA, 2003), Stefan Jeschke, "Textured Depth Meshes for Real-Time Rendering of Arbitrary Scenes" (paper presented at the ACM International Conference Proceeding, Pisa, Italy, 2002).

[156] Seok-Hyung Bae, et al., "Tangible Nurbs-Curve Manipulation Techniques Using Graspable Handles on a Large Display" (paper presented at the 17th Annual ACM Symposium on User Interface Software and Technology, Santa Fe, NM, 2004), C. Bajaj, et al., "Nurbs Based B-Rep Models for Macromolecules and Their Properties" (paper presented at the Symposium on Solid Modelling and Applications, Atlanta, GA, 1997), Robert M. Blomgren, and David J. Kasik, "Early Investigation, Formulation and Use of Nurbs at Boeing," *ACM SIGGRAPH Computer Graphics* 36, no. 3 (2002), Jean-Claude Duguet, "Scientific Apl2 Computing: Bezier, Bsplines, Nurbs (Curves & Surfaces)," *ACM SIGAPL APL Quote Quad* 32, no. 1 (2001), Holger Grahn, "Nurbs in Vrml" (paper presented at the Fifth Symposium on Virtual Reality Modeling Language, Monterey, CA, 2000), Song Han, and Gerard Medioni, "Triangular Nurbs Surface Modeling of Scattered Data" (paper presented at the 7th Conference on Visualization 96, San Francisco, CA, 1996), Ferenc Kahlexa, Akos Balazs, and Reinhard Klein, "Multiresolution Rendering by Sewing Trimmed Nurbs Surfaces" (paper presented at the Symposium on Solid Modeling and Applications, Saarbrucken, Germany, 2002), Subodh Kumar, Dinesh Manocha, and Anselmo Lastra, "Interactive Display of Large-Scale Nurbs Models" (paper presented at the Symposium on Interactive 3D Graphics, Monterey, CA, 1995), William L. Luken, and Fuhua Cheng, "Comparison of Surface and Derivative Evaluation Methods for the Rendering of Nurb Surfaces," *ACM Transactions on Graphics* 15, no. 2 (1996), Michael Shantz, and Sheue-Ling Chang, "Rendering Trimmed Nurbs with Adaptive Computer Graphics and Interactive Techniques," *ACM SIGGRAPH Computer Graphics, Proceedings of the 15th annual conference on Computer graphics and interactive techniques SIGGRAPH '88* 22, no. 4 (1988), Demetri Terzopoulos, "Dynamic Nurbs with Geometric Constraints for Interpretive Sculpting," *ACM Transactions on Graphics* 13, no. 2 (1994), Pifu Zhang, and Fuhua Cheng, "Smooth Connection of Trimmed Nurbs Surfaces" (paper presented at the Symposium on Solid Modeling and Applications, Ann Arbor, MI, 2001).

[157] Wayne E. Carlson, "An Algorithm and Data Structure for 3d Object Synthesis Using Surface Patch Intersections" (paper presented at the 9th Annual Conference on Computer Graphics, Boston, MA, 1982), Robert L. Glass, "Patching Is Alive and, Lamentably, Thriving in the Real-Time World," *ACM SIGPLAN Notices* 13, no. 3 (1978), Axel Kramer, "Translucent Patches--Dissolving Windows " (paper presented at the Symposium on User Interface

Unlike meshes, which function as a covering, subdivision patches fill the cage and are a form of solid modeling. Solid modeling, although ideal for producing realistic 3D imagery, is information rich and of course, dependent upon computer power. The problem of solid modeling would be tackled in an important essay by Ken Perlin in 1988. His "Image Synthesizer" would be widely used in the industry for the solid modeling required in the creation of realistic visual textures like marble, water, waves, fire, clouds, and oil films.[158]

Early modeling techniques exploited shortcuts to get around the numerous difficulties in creating the illusion of solid modeling, by focusing only on the surfaces of an object. In the early 1970s, Edwin Catmull worked on texture mapping as "a method of adding realism to a computer-generated graphic. An image (the texture) is added (mapped) to a simple shape that is generated in the scene, much like a decal pasted to a flat surface."[159] Lance Williams is credited with refining texture mapping in his 1983 essay "Pyramidal Parametrics." He states, "The mapping of images onto surfaces may substantially increase the realism and information content of computer-generated imagery" while reducing the amount of time it takes to render the model.[160]

Another method of adding texture to objects created during the 1970s is bump mapping through which the computer creates "perturbations" at the level of each pixel. A good example of this is to imagine turning a smooth sphere into an orange. An orange skin has small depressions

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Software and Technology, Marina del Rey, CA, 1994), Jian Liang Lin, et al., "Consistent Parametrization by Quinary Subdivision Remeshing and Mesh Metamorphosis" (paper presented at the 1st International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia, Melbourne, Australia, 2003), Chadomay Mandal, "Dynamic Smooth Subdivision Surfaces for Data Visualization" (paper presented at the 8th Conference on Visualization 97, Phoenix, AZ, 1997), Tomoyuki Nishita, Thomas W. Sederberg, and Masanori Kakimoto, "Ray Tracing Trimmed Rational Surface Patches" (paper presented at the 17th Annual Conference on Computer Graphics, Dallas, TX, 1990).

[158] Ken Perlin, "An Image Sythesizer," *Computer Graphics* 19, no. 3 (1988).

[159] Carlson, *A Critical History of Computer Graphics and Animation*.

[160] Lance Williams, "Pyramidal Parametrics" (paper presented at the SIGGRAPH 83 10th Annual Conference on Computer Graphics and Interactive Techniques, Detroit, MI, July 25-29 1983), pp. 1-11.

on its surface and depicting these little dimples would obviously be necessary in creating a realistic-looking orange. Nonetheless, an experienced designer cautions to "keep in mind that although many types of modeling are available, each type boils down to meshes of polygons. A computer cannot render anything but polygons. No matter how smooth a rendered surface may appear to be, somewhere down in the tiny world, straight-edged polygons form your object."[161]

Historically, modeling moves from the use of large, simple polygons to the discovery that greater levels of realism are achieved through smaller collections of polygons concentrated as a 'mesh' on the surface of the object. In this way, modeling abandons smooth surfaces for the granier textures of real-world objects. Early on, it was relatively easy to replicate the homogenous or texturally-consistent surfaces of such things as spaceships, toys, and insects. Again, this early phase of modeling was appreciated on the grounds that it was a novel technique for representing 3D objects, which was considered an important step toward realism, even though the objects did not look real.

One can easily observe innovations in the animation of surface textures by viewing the original *Toy Story* and its sequel, *Toy Story 2*. One creator of *Toy Story* states that originally "shiny objects like Buzz's spacesuit are quite easy to render. Natural fibers, softer surfaces—wrinkles, creases, dirt, clothing, bumps—are harder."[162] In the first film, the 3D representations are plausible and realistic, but the surfaces are shiny and unrealistically uniform. *Toy Story 2*, however, developed coarser textures and surfaces. According to one research paper on crafting realistic surfaces, "The quest for improved realism has always been an important goal for computer graphics. One major difficulty in this process is the extreme complexity of real objects

[161] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 246.
[162] Kaplan, "High Tech in Toon Town: Why the Computer-Generated Hit *Toy Story* May Change the Business of Animation Forever."

which exhibit many subtle variations over their entire surface. In contrast, synthetic objects often look 'too perfect;' to achieve realistic synthetic images, these subtle variations need to be simulated."[163] Proprietary or "plug-in" software is now included in animation interfaces and is continually being developed to improve the emulation of real life surface imperfections like pores, corrosion, and the general surface irregularities of fur, hair, or grass.

Another major innovation in constructing organic imagery and objects is the temporal processes of acceleration and morphing. Morphing constitutes a continuous transformation from one thing or object into another. "Morphing is a 2D effect that smoothly transitions between corresponding points of two different images. Some form of curve mesh is placed on arbitrary points of two images. It then transitions the position of these points while cross-fading to the other image."[164] The first use of computer code to create a 2D morph occurred in the film *Willow* (1988) when a character turns into several different animals, which was achieved through traditional stop-motion techniques. With the advent of more advanced 3D algorithms however, morphing is much more seamless and organic in appearance. As discussed earlier, one of the goals associated with realism to which digital designers attend, is the creation of surface imperfections by focusing on the natural forces of time and environment. Many animation techniques focus on artificially accelerating natural rhythms that are normally imperceptible. In one such experiment, "Surface Aging by Impacts," the designer attempts to simulate

> the effects of complex aging processes" on the surfaces of metals. The motivation behind the creation of realistic models is that "one such important effect is the cumulative aging that affects all real objects. Detailed synthetic objects and environments rarely reflect the fact that people, objects, chemicals, etc., affect them over the course of time, increasing their complexity. Aging processes are

[163] George Drettakis, Eric Paquette, Pierre Poulin, "Surface Aging by Impacts" (paper presented at the Graphics Interface 2001, 2001), Kaplan, "High Tech in Toon Town: Why the Computer-Generated Hit *Toy Story* May Change the Business of Animation Forever."
[164] Masson, *CG 101: A Computer Graphics Industry Reference*, p. 118.

> numerous: abrasion, stains, peeling, dust, scratches, compaction, oxidation, etc.[165]

The designer seeks an "aging technique that simulates the deformation of an object caused by repetitive impacts over long periods of time" to deteriorate an object "by hitting it with another object."[166] Similarly, in one conference paper, a team of software designers explore the possibility of integrating a corrosion effect into a computer graphics interface. "Real-world surfaces are often covered by lots of imperfections due to various aging processes . . . Aging and weathering effects can take many different forms such as dust accumulation, patinas, moisture, scratches, erosion, etc."[167] Naturally-occurring corrosion is difficult to simulate because "of the huge amount of different reactions, different conditions and different materials."[168] In addition, many digital animators are interested in accelerating normal temporal rhythms like organic decay for both scientific and entertainment purposes. "Manually modeling the effects of complex aging processes is time-consuming: effective tools are needed to speed-up the design process."[169]

Again, the idea is to write algorithms that mimic real-world physics—even if the effect is utterly fantastic (a human morphing into a werewolf, for example) the metamorphosis must be plausible on a physiological level. This commitment to the simulation of the minutiae of real world phenomena shows how the organic reality asserts itself constantly as a standard of comparison and as an obstacle to modeling that must be overcome.

The central paradox in modeling 3D objects in virtual space is that objects that retain realistic flexibility and texture, are designed via increased levels of abstraction through purely mathematical representation, i.e., formulas, code, and algorithms. According to one animator,

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[165] Drettakis, "Surface Aging by Impacts," p. 175.
[166] Ibid., p. 175.
[167] Ibid., p. 175.
[168] Jean-Michel Dischler, Djamchid Ghazanfarpour & Stephane Merillou, "Corrosion: Simulating and Rendering" (paper presented at the Interface Graphics 2001 Conference, 2001), p. 167.
[169] Drettakis, "Surface Aging by Impacts," p. 175.

> If you look at the future, where this is all heading, it's becoming more and more script driven, because packages are now open, so we can use something like MEL [Maya Embedded Language] to make the software do what we need it to do. That's the power we need. With MEL, there are built-in mathematical functions, so you can dig into the software and manipulate it with math, which is a growing need.[170]

We usually associated organic reality with three-dimensional materiality. However, the appearance of objects that you could almost reach into the screen and grab (and indeed can in many virtual reality and augmented reality interfaces) are created via a language that is historically and culturally, considered to be abstract, and "flesh free." It seems that purely symbolic language, a language without reference to "reality," "things," or "objects" in the world offers a medium that to date, is the chosen method for the representation and simulation of organic processes. The word "chair" refers to a thing or concept, in a way that the number "two" does not. This theory of mathematics may be contested since, like all cultural systems, it is subject to contextual influences. However, I agree with Lev Manovich's claim that representation through mathematics is an unprecedented cultural form that demands closer scrutiny and critique.

An important innovation in 3D model design is called "physically based models." As discussed earlier, realism in computer graphics seeks to copy natural phenomena. Another good example of this is the use of already existing geological information to create virtual scenes. Physically-based modeling, like scanning real world textures, sometimes serves as yet another form of skirting the problem of building models from the ground up. It is also a method of copying already-existing algorithms. Once you write a code for a particular effect, it can be used again and again. For example, Andrew Witkin was recognized by SIGGRAPH for his physics-based approach to computer graphics in 2001 by creating a Maya plug-in for cloth simulation.

[170]Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 10.

His algorithm was first used in *Stuart Little*, and again in *Monsters, Inc.* which was Pixar's first extensive use of physical simulation in a feature film. "Pixar animators directly controlled the movements of the characters' bodies and faces, but much of their hair and clothing movement was computed using simulations of Newtonian physics. Physical simulation allowed a degree of realism of motion that would not have been possible with traditional methods."[171]

Physically-based modeling goes further than merely copying the textures of fabric, skin, and hair. This technique also refers to the creation of so-called intelligent models. Engineers of physically-based modeling began researching ways to simulate the actual behavior of objects and phenomena. Several important contributions to this field include papers on "deformable models" which are models capable of movement or transformation.[172] A leading researcher in this field, D. Terzopoulous, claims that

> Physically-based techniques facilitate the creation of models capable of automatically synthesizing complex shapes and realistic motions that were, until recently, attainable by skilled animators, if at all. Physically-based modeling adds new levels of representation to graphics objects. In addition to geometry—forces, torques, velocities, accelerations, kinetic and potential energies, heat, and other physical quantities are used to control the creation and evolution of models. Simulated physical laws govern model behavior, and animators can guide their models using physically-based control systems. Physically-based models are responsive to one another and to the simulated physical worlds that they inhabit.[173]

[171] Carlson, *A Critical History of Computer Graphics and Animation* .
[172] Demetri Terzopoulos, "Artificial Life for Computer Graphics," *Communications of the ACM* 42, no. 8 (1999), Demetri Terzopoulos, "Perceptive Agents and Systems in Virtual Reality" (paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, 2003), Demetri Terzopoulos, "Visualizing Modeling for Computer Animation: Graphics with a Vision," *ACM SIGGRAPH Computer Graphics* 33, no. 4 (2000), Demetri Terzopoulos, et al., "Behavioral Modeling and Animation (Panel): Past, Present, and Future" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1998).
[173] Kurt Fleischer, and Demetri Terzopoulos, "Modeling in Elastic Deformation: Viscoelasticity, Plasticity, and Fracture" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1988).

Physically-based modeling gathers together the disciplines of biology and computer science. As a result, the study of autonomous systems overlaps with the field of artificial intelligence since these programs are designed to reproduce the behavior of organisms and ecosystems. One way that the computer graphics industry creates realistic 3D imagery is by endowing their models with a certain level of autonomy and responsiveness to a given environment.

Another form of realistic modeling drew from Benoit Mandelbrot's book, published in 1975 and in English in 1982, *The Fractal Geometry of Nature,* in which he argues that fractals occur in a wide variety of natural processes. "A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale."[174] Again, the link between the purely mathematical and the natural would turn out to be crucial to the development of realistic computer graphics. Even though realistic objects are really just collections of small polygons (not 'real' in any material sense but pure mathematical abstractions), due to the corresponding patterns of nature, collections of shapes are a realistic way to represent the world. The logic of fractals is also a type of "golden mean" in that they lend unprecedented flexibility to digital models in that the scale of a model remains consistent. Each fractal is independent of the surrounding fractals and therefore can be removed, cut, pasted, and manipulated in many ways without damaging the whole. As outlined by Lev Manovich, this principle of modularity is a basic component of digital technology and illuminates the manner in which computer science grew out of mathematics and geometry.[175]

Like physically-based modeling, fractal geometry led to computer animation programs based on principles of artificial intelligence and systems theory. For instance, Bill Reeves' paper

[174] Carlson, *A Critical History of Computer Graphics and Animation*.
[175] Manovich, *The Language of New Media*, p. 30.

on Particle Systems, published in 1983, "addressed the problem of generating highly complex imagery of an organic nature—how to control motion, change of form, dynamics, and surface characters of the models in the scene."[176] One early example of fractal animation displayed in SIGGRAPH's Digital Theatre in 1987, was Craig Reynolds' short film, *Stanley and Stella in Breaking the Ice,* which depicts flocks of birds in the air above a body of water containing schools of fish. According to Reynolds, "typical computer animation models only shape physical properties of the characters, whereas behavioral or character-based animation seeks to model the behavior of the character."[177] Fractal technology was first used as a special effects technique in the film *Star Trek II: The Wrath of Khan* in which a realistic mountain range is depicted. Recently, software based on fractal geometry has lead to the use of flocking and crowd behavior in such films as *Batman Returns*, *Star Wars,* and *Titanic*.[178] Modeling based on the physical attributes of large-scale, naturally-occurring phenomena and fractals have changed attitudes toward representation because they signal an era of interaction with intelligent or "living" models.

What we gain from an analysis of the history, practices, and goals of the computer graphics industry is a more nuanced understanding of the drive toward photorealism. While it is true that digital representation borrows from film conventions, the industry's definition of realism departs from the cinematic tradition in significant ways. This select history of the goals of achieving photorealism shows that animators and interface designers want to copy organic reality. In other words, they are trying to create intelligent models, characters, and creatures that are capable of adapting and responding to their environment in an autonomous way. Innovations in graphics that improve upon these techniques would become integral to the computer games

[176] Carlson, *A Critical History of Computer Graphics and Animation*.
[177] Ibid.
[178] See Robertson, Barbara in *Computer Graphics World,* articles from 1998 through 2003.

market. Why are professionals obsessed with realism? Simon Penny provides a useful definition of photorealism when he argues that

> this call for the representation of the 'organic' is a call for greater mimesis in computer graphics. But why this obsession with micro-graphic representationalism? There is an implicit assumption that computer graphics must emulate and exceed the mimetic capability of representational painting and of photography in its representation of organic form according to Renaissance pictorial conventions.[179]

Penny places computer graphics realism within a long-term trajectory beginning with oil paintings. However, the gap between industry standards and goals and the practical results, is the theme of the following chapters. It is not surprising that the quest for photorealism resembles a mythological tale of the search for the Holy Grail. The process of artificially copying natural phenomena is a process of endless deferral. Like seeking gold at the end of the rainbow, the prize is always just out of reach. As we will see in subsequent chapters, this attempt to make a perfect copy never results in a perfect copy, but creates formal and material residual effects, visible in the end product. This is also true of the process of creating the actual tools or interfaces that end-users (animators and designers) will use to create realistic scenes. The next chapter explains the design goals in the field of creating interfaces for animators.

[179]Simon Penny, "Virtual Reality as the Completion of the Enlightenment Project," in *Culture on the Brink: Ideologies of Technology*, ed. Gretchen Bender, and Timothy Druckrey (Seattle: Bay Press, 1994), p. 233.

3.0 CHAPTER 2:
THE DISAPPEARING MEDIUM: TRANSPARENCY, TANGIBILITY, AND TRANSCENDENCE IN INTERFACE DESIGN

> *Using most of today's digital products is like driving a car that has been rolled down a cliff: You must climb in through the window, none of the lights seem to work, the engine makes a suspicious clunking noise, and spans of sheet metal fly off at inopportune moments.*[180]

In the prior chapter, I discussed the process and practice of digital animation and the industry goal of photorealism. However, all digital designers require a tool that allows them to communicate with the computer. This tool is called a graphical user interface (GUI). The graphical user interface, pronounced "gooey" among professionals, "refers to the graphical menus and buttons on a computer program that allow user manipulation of the program itself."[181] It is the mechanism or tool used by a human operator to interact with a computer in order to translate computer language into human language. According to a leading designer, Theo Mandel, "the computer's interface includes the hardware that makes up the system such as a keyboard, a pointing device like a mouse, joystick, or trackball, the processing unit, and the display screen itself."[182] Yet, he also notes that he would like to broaden this definition to include "the whole experience between the user and the computer."[183] The interface for digital animation is the mechanism through which the operator accesses and deploys the software platform and

[180] Alan Cooper, and Robert Reimann, *About Face 2.0: The Essentials of Interaction Design* (Indianapolis, IN: Wiley Publishing, Inc., 2003), p. 99.
[181] Masson, *Cg 101: A Computer Graphics Industry Reference*, p. 15.
[182] Theo Mandel, *The Elements of User Interface Design* (New York: John Wiley & Sons, Inc., 1997).
[183] Ibid., p. 14.

architecture that govern the organic textures, volumes, and movements of both real and 'fantastic' things. Further, although the interface represents a medium similar to other types of 'screens' such as in film and television, it is not meant to be viewed passively (i.e., non-interactively) by audiences. Rather, the animation interface invites the user to interact with virtual objects. Similar to contemporary practices in animation, interface design is increasingly guided by a desire to create intelligent software. In other words, designers try to make interfaces responsive to users and sensitive to the environments in which they are being used. However, the technological workings that render the interface "smart" are to be hidden from the user's view.

In this chapter, I will discuss the goals of the interface design industry, such as the use of real-world metaphors, the concern with creating intuitive tools, a prevalent interest in designing tangible user interfaces, the problem of ergonomics, and the overarching longing to achieve transparency. Last, I will critique these goals by observing that the metaphysical logic to designing user interfaces is to produce a type of transcendence in the user in the sense that they are supposed to forget about the embodied obstacles to accessing the computer. I conclude that the difficulties associated with these design goals arise from a confusion concerning the relationship between the human mind and body, and the computer's material form and symbolic content. In what follows, I will first explain what a GUI is before proceeding to a discussion of design practices within the field. I will show that interface design is deeply imbued with attitudes toward the mind and body that have been part of western culture for centuries.

There are many different kinds of interfaces in addition to those used for computer animation and virtual reality. Within this chapter I will refer to those used for animation, yet at the same time, many of the insights gained from looking at interfaces designed to do other things will be examined as well. . Other types of interfaces include those that are created only for

designers (architectural, artistic, engineering, scientific), programs designed solely for entertainment or educational purposes (gaming, interactive learning), and programs designed to accomplish work tasks (Microsoft Word, Excel). There are interface programs that are sold commercially and are accessible to everyone (Photoshop), as well as programs designed for particular companies like Pixar and Industrial Light and Magic to meet their unique needs. Obviously interface design is a vast and varied discipline, encompassing many different products for many different institutional and private contexts. Even style or types of interfaces vary across contexts and define the sub-disciplines within interface design as a whole. For instance, augmented reality, tangible interface, and human-computer interaction, are just a few of the sub-fields within interface design. Therefore, many of the industry goals that I will discuss apply widely to interface design. Techniques such as the use of real-world metaphors apply to both word processing programs and animation programs like *Maya*. On the other hand, some types of interface design seem to defy conventional rules that apply across the board. Gaming is one such example. Whereas many interfaces designed to complete standard 'work' tasks deploy particular strategies to control and enable the user, the design ideology for these interfaces do not necessarily apply to software used for entertainment purposes. For instance, many games expect constraints to be regularly violated by the user while word processing interfaces do not. As I move through this chapter, I will be more specific about what these design conventions are and provide examples of the types of interfaces they apply to. I will also clarify why some design techniques apply to one situation and not another.

Culturally, the screen is one of the most important elements in human-computer interaction. In simple terms, or at least in terms of the average user, the interface is literally, the computer screen. "Most nontechnical computer users imagine that their video screen is the heart

of their computer. This is only natural because the screen is what they stare at all the time and is the place where they see what the computer is doing."[184] However, the screen as a cultural artifact is deceptively simple. As this chapter will elaborate, the screen defines a symbolically- and materially-rich environment for complex intersections between the human body and the technological body (hardware). In other words, instantiated within design ideology is the idea that most computer functions must be hidden from the user. In the conventional sense of the term then, the screen functions as a barrier that separates the viewing subject from the workings of the computer, rather than functioning as a transparent window through which the user peers. This fact is all the more extraordinary when one considers that the driving goal within software design today, is precisely to render the screen transparent. The user must forget that the interface is there. This goal is also consistent with the technical history of film and television, whereby the screen usually presents a seamless representation that removes aspects of production from view.

The screen is important to interface design because it comprises a familiar convention for users and this fact is well known to designers. In other words, we approach a screen with certain expectations about how it works since other types of screens such as television and film, have long been among our cultural tools. Most importantly, these cultural aspects, although profoundly contextual, are not merely the result of symbolic forces. Rather, they materially instantiate historical conventions governing media technology.

The texts that we interact with, Manovich refers to as "cultural data" which include "websites, CD-ROM and DVD titles, multimedia encyclopedias, on-line museums and magazines, computer games, and other new media culture objects."[185] Manovich clarifies the different types of cultural objects that require separate kinds of interface tools: the printed word,

[184] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 25.
[185] Manovich, *The Language of New Media*, pp. 69-70.

cinema, and human-computer interaction. Each of these represent work related interfaces like word processing, databases, and spreadsheets, entertainment related interfaces like gaming and digital animation; and largely experimental artificial intelligence tools like augmented reality, intelligent and tangible user interfaces.

Many of the general principles I describe in this chapter inhere in all of these different categories. Studying the material aspects of a computer such as the screen, keyboard, and mouse are essential to grasping the cultural implications of these mechanisms. Therefore, the screen instantiates conventions that is both cultural and material.

One of the most celebrated features of the personal computer is its capacity for interactivity and the manner in which it affords the user a tangible grip on objects in virtual space. Rather than acting solely as a means of displaying an image of reality, the screen becomes a vehicle for directly affecting reality. Many scholars of new media have commented upon this seemingly revolutionary aspect to the production of media texts. However, the much-lauded interactive component is sharply curtailed by the fact that: first, constraints are usually designed into the program to prevent certain actions from taking place, and second, interfaces remain intimidating, inaccessible, and bewilderingly complex for most users—particularly aspiring digital animators. Making interfaces easier to use is perhaps the single most important design goal in the industry today.

Whether or not they conceive of their users as intelligent explorers or ignorant wanderers who stumble across new ways of doing things quite by accident if at all, designers are obsessed with a desire to understand their audience. In fact, usability testing comprises a significant expenditure of resources within the field.[186] The obstacle to reaching this goal, however, occurs in the necessity to strike a balance between sophistication and ease of use. There is no escaping

[186] Reimann, *About Face 2.0: The Essentials of Interaction Design*, pp. 39-71.

the fact that interfaces are complex and robust programs that contain "depths" that most "persistent intermediates" will never discover. Further, designing an interface requires the efforts of a variety of disciplines, not least among them is cognitive psychology, because the real applications of the interface in the hands of its users is largely undetermined. In other words, good interface design recognizes its status as a mediation tool in that its actual uses remain undetermined. Therefore, design goals are also shaped by the need for malleability.

Interface designers are more concerned with the way the software behaves rather than accuracy of representation or having one fixed goal that the interface is designed to do. "Simply put, interaction design is the *definition and design of the behavior of artifacts, environments and systems,* as well as the formal elements that communicate that behavior. Unlike traditional design disciplines, whose focus has historically been on form and, more recently, on content and meaning, interaction design seeks first to plan and describe how things *behave* and then, as necessary, to describe the most effective form to communicate those behaviors."[187] Clearly, the design of such a tool is formidable. It is accurate to claim that a good interface must be both, simple and complex, accessible and inaccessible (aspects of the interface are hidden until the user is 'ready' to use them), rule based yet malleable. How do designers tackle these problems and with what rate of success? More importantly, what kinds of cultural attitudes toward users and digital design are realized in the process of creating an interface? This chapter will address these questions by first discussing the thorny issue of usability in terms of the successes or frustrations experienced b users.

Like computer graphics, the design of graphical interfaces is driven by one goal; to make interfaces easier to use. Animators must have an interface to create computer graphics. But there is considerable overlap between these seemingly separate disciplines. Many animators create

[187] Ibid., p. xxix.

their own interfaces as well as customize existing ones by tweaking programming and modeling languages like C++ and VRML.[188] As with the history of filmic apparatus, those who design the technology are also those that are the first to tinker with content creation.

Since computer interfaces can be very difficult to master, in particular interfaces designed for computer animation, accessibility drives the industry. Professional papers, and research in the field of computer graphics continually underscore their goal of making the interface easier to use. A typical abstract describing the goals of one conference paper outlines the interest in making these programs accessible for beginners.

> We are interested in addressing the needs of the novice animator who is not necessarily artistically skilled or familiar with keyframing interfaces. From our experience observing novice animators, it is clear that setting keyframe values is straightforward while specifying the keyframe timing is difficult and time consuming. We present a novel method for novice users to time keyframes using gestures without changing the motion itself . . . Our approach allows the user to 'act-out' the timing information using a simple 2D input device such as a mouse or pen-tablet."[189]

A consideration of user psychology, cognitive models, and perception continues to be of major importance to designers today. Software engineers continually keep the user in mind, by trying to decrease the intimidating learning curve of animation programs. Of literally thousands of conference proceedings on computer graphics, tangible and interactive interfaces, virtual reality and augmented reality, researchers demonstrate their interest again and again in making the interface more accessible for beginners. "People don't need to know all the details of how a complex artifact actually works in order to use it, so they create a cognitive shorthand for

[188] C++ is "an object-oriented, high-level programming language used by many modern software designers." VRML (virtual reality modeling language) "is simply a 3D interchange format" that "defines most of the commonly used semantics found in today's 3D applications such as hierarchical transformations, light sources, viewpoints, geometry, animation, fog, material properites, and texture mapping." Masson, *CG 101: A Computer Graphics Industry Reference*.

[189] S.C.L. and R. A. Metoyer Terra, "Performance Timing for Keyframe Animation" (paper presented at the Symposium on Computer Animation, Grenoble, France, 2004), p. 253.

explaining it, one that is powerful enough to cover their interactions with it, but which doesn't necessarily reflect its actual inner mechanics."[190] "Cognitive shorthand" refers to the use of real-world metaphors which will be discussed later in this chapter.

The practices and goals of interface design far exceed personal uses, since a large percentage of research into interface design is meant for commercial, industrial, educational, medical, and scientific realms. I will explore the problems and difficulties that have plagued both the use and design of animation interfaces by using an example that is widely used in both personal and professional contexts—*Maya* by Alias/Wavefront. *Maya* is one of the most sophisticated and complex, yet enduring programs for digital animators. Among other software for digital compositing, editing, and post-production procedures, its' character modeling features have been used in such films as *Lord of the Rings* and *Final Fantasy.* It has been called a 'robust' program by professionals in the field because it provides the depth of functions necessary to stay in step with industry demands. "Both Softimage XSI from Avid and Alias/Wavefront's *Maya* are at the top of the difficulty spectrum. These programs are difficult to learn out of the box and are deep in facilities."[191] The complexity of these programs can be very intimidating to new users. In fact, an amateur could use the program successfully without ever discovering its many nested or "embedded" functions. In industry jargon, "drilling down" refers to the gradual process of uncovering all of the features of the program.[192] "Animation programs are so robust they cannot possibly display all their tools and features in one screen. Consequently, some method of navigation is featured in each program. The most common method is to feature a range of

[190] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 21.
[191] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 174.
[192] Ibid,. p. 176.

category buttons."[193] These are arranged in a hierarchy of categories, sub-categories, and sub-sub-categories and learning these pathways is very time-consuming. For example, once software engineers or individual animators have designed a procedure for rain, they can customize a tool that will automatically produce rain.

However, the malleability of animation programs like *Maya* also guarantees adaptation to ever changing professional demands. Adapting to the rapidly changing technological landscape is crucial for staying competitive in a very tough animation software market. The process of writing code and creating customized functions is based on the computer engineering language of C++, with which most end users are not, and need not be familiar. On the other hand, computer scientists may not possess the artistic sensibility and skills that are also absolutely crucial to being a successful animator. Interface design must grapple with these twin and usually opposing skill sets: programming and animating. One professional animator asks, "Why can't a program be both easy to learn and deep? Could it be that the deep program manufacturers, while interviewing users in focus groups, have identified difficulty as a *positive* attribute? Hanging out with some *Maya* and SXI animators, there definitely seems to be a kind of fraternal atmosphere in the air, perhaps bred from hazing and tortuous *rites de passage.*"[194] The author's joke here is not far from the truth. Like most professions, digital animation enjoys an extensive vocabulary of insider jargon and that jargon is, in part, designed to keep upstarts out by guaranteeing the need for special training. But unlike most professions, this elaborate set of labels and symbols refer to concrete practices that take place in virtual space versus real space.

Maya deploys an impressive, and potentially bewildering, array of icons and terminology. "With all the toolbars and panels open at once, one might think that very little room is left for

[193] Ibid., p. 176.
[194] Ibid., p. 175.

displaying the animation in the viewports. One might think correctly!"[195] An examination of threaded discussions on the Aliaswavefront Webpage reveals a flurry of desperate questions from beginners. Some of the problems encountered by amateurs when using *Maya* include creating elastic surfaces, time lapse clouds, transparency, glass, fur, hair, blood and bone systems, wire frames, clothing, crowds and aliens.[196] One user wondered why his screen was totally black after the rendering process. A more experienced animator gently chided him to "turn on the lights." Unfortunately for beginners, the language and architecture of *Maya* and other leading animation programs like *Lightwave* and *3Ds Max,* are committed to two, somewhat opposing goals. The program should be sophisticated enough to allow expert users to exploit its various operations as they become more accustomed to using the software. Program complexity refers to multiple levels of nested functions with increasing complexity and sophistication. The ongoing challenge for software engineers is to sacrifice neither ease of access for novices, nor the robustness required for adepts who are able to customize their tools to fit certain animation jobs.

> If judiciously applied, animation techniques can enhance the look and feel of computer applications that present a graphical human interface. Inflecting an interface means organizing it to minimize typical navigation. In practice, this means placing the most frequently desired functions and controls in the most immediate and convenient locations for the user to access them, while pushing the less frequently used functions deeper into the interface, where the user won't stumble over them.[197]

One feature of animation programs, however, is the extremely wide gap between the easy-access buttons and the deep architecture. In other words, skilled animators can customize the interface by tweaking the program language itself. Further, like most digital representations,

[195] Ibid., p. 197.
[196] http://www.alias.com/eng/support/maya/
[197] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 154.

animation is information-rich and time intensive. Therefore, it requires powerful and computationally smart machinery to process models and scenes. Last, although design metaphors drive the goals of the industry to a large extent, these are particularly difficult to use in animation software because the process of designing scenes and characters is becoming increasingly more conceptual. How do you create pictures to represent operations like 'bend,' 'twist,' and 'pull?' Although designers would like to think that individuals who are new to the interface can easily sit down and master some of these processes, the reality is that these actions must be learned. Other functions symbolized through the software's iconography include such complex operations as grabbing, stretching, extruding, lathing, skinning, rotating, squashing, adding layers, removing layers, deforming elements, and many more.

A much discussed and celebrated technique for making interfaces easier to use is the consistent deployment of a "real-world design metaphor." Design metaphors are meant to encourage an "intuitive" relationship between human user and computer. The terms "metaphor" and "intuitive" are notoriously slippery terms since they contain both traditional definitions as well as arbitrary or professional meanings unique to the computer science field. Both terms are used regularly in professional literature as catch-alls to describe the goals of accessibility.

The most well-known metaphor for interface design is the "desktop." Folders, trashcans, briefcases, and documents are all referred to as metaphors. Therefore, within the industry "metaphor" entails a much more iconic meaning than a linguistic one. "When we talk about metaphors in the context of user interface and interaction design, we really mean visual metaphors: a picture used to represent the purpose or attributes of a thing."[198] The use of the term metaphor in the profession does not really entail the conventional definition of using one idea or object to gesture toward a different idea or object. Metaphors are usually conceived of

[198] Ibid. p. 248.

paradoxically, as using a dissimilar example to evoke a secret relationship between these seemingly unlike things. According to a famous distinction made by Hans Blumenberg, the use of metaphor refers to a process whereby we:

> Comprehend something as something is radically different from the procedure of comprehending something by means of something else. The detour by which, in metaphor, we look away from the object in question, at another one, which we imagine may be instructive, takes the given as something alien and the other as something more familiar and more easily at our disposal.[199]

Iconography, pictorial representations of an object versus linguistic ones, on the other hand are understood within the tradition of art history as a collapse of meaning and symbol, beginning with Early Christian and Byzantine art. Within this tradition, the pictures of Christ or the Madonna and Child are stock images that are thought to contain the essence of the thing represented. "These original, 'true' sacred images were supposedly the source for the latter, man-made ones."[200] "Because of the veneration in which they were held, icons have to conform to strict formal rules, with fixed patterns repeated over and over again."[201] This is also true in interface design, where consistency is a governing rule. Further, interface design, like rendering in animation, is an iterative process and like the quote above indicates, fixed patterns are repeated over and over again, especially in the consistent use of iconic images from one interface to another.

The use of icons in interface design is, of course, a notably secular endeavor. But unlike the traditional use of metaphor, interface design techniques do not seek to "take a detour" away from the object or process described by the picture. Instead, they seek to represent the essence of the action or object within it. Like Medieval iconography, which is virtually incomprehensible to

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[199] Hans Blumenberg, "An Anthropological Approach to the Contemporary Significance of Rhetoric," p. 439.
[200] H. W. Janson, *History of Art*, 3rd ed. (New York: Harry N. Abrams, Inc., 1986), p. 228.
[201] Ibid., p. 228.

a contemporary audience, interface iconography is culturally specific and learned. Knowing that a picture of a phone signifies a portal to the Internet is not a universal or atemporal symbol. Neither is the presence of a dove in medieval iconography understood across cultures and time periods to represent the holy spirit, nor is a white lily a signifier of purity. Other examples of visual icons in interfaces might be a wastebasket or a hand that clutches onto objects and pages. Although, as I will show later in this chapter, the profession is gradually moving away from the metaphor model that has been a dominant design convention for a long time within the profession. Nevertheless, it is still used in the literature to describe the overall organizational scheme of the interface. The best known example of a 'global' metaphor is the desktop metaphor now widely used in most personal and professional computing devices. In fact, for computer generation users, naïve of the command-line, text-driven era of computing, it seems like a natural way to approach the computer. In other words, in a conventional and hence, learned sense, the typical desktop metaphor seems invisible.

Design metaphors are meant to produce a sense of intuitive actions in users who are confronting an interface for the first time. Again, the goal is to make human-computer interaction more natural. Intuitive design refers to attempts to reduce the learning curve of interface mastery. The idea is that if the objects and tools on the interface reflect a real world metaphor, then users will simply approach the interface as they would objects in the real world.

Like the term metaphor, the term intuition also carries overtones of its conventional meaning, as well as instantiating meanings that are specific to the cultural milieu of digital designers. Professionals in the field understand intuition in a far more practical sense than the term suggests. According to the *Oxford English Dictionary*, one meaning of the term and, perhaps the most familiar, is, "The spiritual perception or immediate knowledge, ascribed to

angelic and spiritual beings, with whom vision and knowledge are identical."[202] The conventional meaning of intuition entails a certain psychic sensibility, or gut feeling that has nothing to do with the details of human cognition to which the computer industry is so indebted. Intuition suggests a type of revealed knowledge that bypasses the problem of learning, expectations, and past experiences. Often, people are thought to intuit things on a visceral basis in that they simply feel, both physically and emotionally, that something is or is not the case. According to Raskin, a critic of contemporary interface design metaphors, within the industry practice intuition does not refer to "knowledge acquired without prior exposure to the concept, without having to go through a learning process, and without having to use rational thought." He adds that intuition is really being used synonymously with "familiarity."[203] Nonetheless, the use of the term intuition is still prevalent in contemporary literature on interface design today.

For instance, one designer explains that

> Modeling and animating complex volumetric natural phenomena, such as clouds, is a difficult task. Most systems are difficult to use, require adjustment of numerous, complex parameters, and are non-interactive. Therefore, we have developed an *intuitive*, interactive system to artistically model, animate, and render visually convincing volumetric clouds using modern consumer graphics hardware.[204]

This example of an interface designed for animation shows that rendering objects and scenes is quite difficult and complex. These designers promise to deliver an easy-access "intuitive" modeling system. Similarly, another paper argues that, "Our system provides a simple, *intuitive* and fast interface for creating rough animations that leverages users' existing

[202] "The Oxford English Dictionary," ed. J.A. Simpson and E.S.C. Weiner (New York: Oxford University Press, 1989).
[203] Jef Raskin, *The Humane Interface: New Directions for Designing Interactive Systems* (New York: Addison-Wesley and the ACM Press, 2000), p. 150
[204] David S. Ebert, Charles Hansen, Joshua Schpok, and Joseph Simons, "A Real-Time Cloud Modeling, Rendering, and Animation System" (paper presented at the Symposium on Computer Animation, San Diego, CA, 2003), p. 160.

ability to draw."[205] Yet another experiment in creating accessible interfaces claims that, "this paper presents an interactive morphing framework to empower users to conveniently and effectively control the whole morphing process. Given two polygonal meshes, users can choose to specify their requirements either at the global level over components or at the local level within components, whichever is more *intuitive* . . . Therefore, user control is greatly enhanced and even an amateur can use it to design morphing with ease."[206] Each of these examples stating the design goal of intuitiveness is representative of a large number of projects within the field.

Despite its ambiguity within the field, intuitive interface design has its critics. "In the computer industry, and particularly in the user-interface design community, the word intuitive is often used to mean easy-to-use or easy-to-understand. Ease-of-use is obviously important, but it doesn't promote our craft to attribute its success to metaphysics. Nor does it help us to devalue the precise meaning of the word."[207] According to Cooper and Reimann, the use of the term intuitive to describe the goals of interface design is misleading. He connects the term, rather unclearly, to an aspect of 'metaphysics.' Within the context of this passage, metaphysics refers to the mystical or mysterious aspects of how humans can more or less instinctively grasp a concept without having to learn it. Cooper and Reimann assert that what is really meant by intuitive design is learnability. "One of the most laudatory terms used to describe an interface is to say that it is 'intuitive.' When examined closely, this concept turns out to vanish like a pea in a shell game and be replaced with the more ordinary but more accurate term 'familiar.'[208] One critic of intuitive iconography argues that these metaphors are linked to outmoded, mechanical age

[205] Maneesh Agrawala, Erika Chuang, James Davis, Zoran Popovic, David Salesin, "A Sketching Interface for Articulated Figure Animation" (paper presented at the Symposium on Computer Animation, San Diego, CA, 2003), p. 320.
[206] Hong-Yang Ong, Tiwo-Seng Tan, Yongguan Xiao, and Yonghong Zhao, "Interactive Control of Component-Based Morphing" (paper presented at the Symposium on Computer Animation, San Diego, CA, 2003), p. 339.
[207] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 249.
[208] Raskin, *The Humane Interface: New Directions for Designing Interactive Systems*, p. 149.

metaphors prevent the introduction of more useful design techniques. "It is only natural for us to try to draw the imagery and language of an earlier era that we are comfortable with into a new, less certain one."[209] Therefore, "Don't replicate mechanical age artifacts in interfaces without information-age enhancements."[210]

These warnings echo Walter Benjamin's theory of the fossil, as a metaphor for a cultural artifact that retains the remnants of a bygone age. As explained by Susan Buck-Morss, "in the image of the fossil, Benjamin captures as well the process of natural decay that marks the survival of past history within the present, expressing with palpable clarity what the discarded fetish becomes, so hollowed out of life that only the imprint of the material shell remains."[211] Although Benjamin was referring to the nineteenth century Paris Arcades when he devised the remarkably efficacious archaeology metaphor, the term is still suitable today. The fossil shows up in a context where the applications and cultural uses for new technologies are uncertain and therefore, are coined by referencing the more familiar forms of the past. Benjamin uses the example of a "horseless carriage" to describe the early term for an automobile. And as Manovich has elaborated, digital media borrows extensively from film conventions in their very design logic. Raskin, in critiquing the use of outmoded forms, argues that icons can be quite misleading.

> Icons contribute to visual attractiveness of an interface and, under the appropriate circumstances, can contribute to clarity; however, the failings of icons have become clearer over time. For example, both the Mac and Windows 95 operating systems now provide aids to explain icons: When you point at the icon, a small text box appears that tells you what the icon stands for . . . Why not just use the words in the first place? Instead of icons explaining, we have found that icons often require explanation.[212]

[209] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 235.
[210] Ibid., p. 29.
[211] Buck-Morss, *The Dialectics of Seeing: Walter Benjamin and the Arcades Project*, p. 160.
[212] Raskin, *The Humane Interface: New Directions for Designing Interactive Systems*, p. 168.

The author laments that more designers do not take advantage of the fact that "today we have the luxury of rendering our communications interfaces in any way we please . . . yet we insist on holding these concepts back with representations of obsolete technology."[213]

The design ideology of intuitive interfaces offers the alluring but deceptive longing for direct, unmediated access to computing technology, and by extension to virtual reality. However, real-world metaphors designed to promote transparency are quite illusory. They do not necessarily behave like objects in the real world even though design goals seem to suggest that familiarity is a good design principle. For instance, the waste basket on a typical desktop is a misleading metaphor. In real life, when you put things in a wastebasket consciously, you rarely go rummaging around inside it again. You would normally consider that object to be out of your life for good. However, in the desktop interface, the wastebasket functions as a storage device. One would think that after assuring the computer that yes, 'you really, really want to delete this thing' that it would disappear. However, clicking on the wastebasket reveals a list of discarded items that must in fact, be deleted again.

One might think that with the design goals of intuition and accessibility, that animation software would provide ever higher levels of freedom for relatively inexperienced users. Given this revolutionary new terrain of virtual space, all that is needed is the key, in the form of a well-designed interface, to unlock the door to unlimited creativity. However, such claims disguise another important goal in interface design which is deliberately meant to prevent the user from accessing certain computer capabilities. In some ways, the interface restricts what can and cannot be done in the so-called limitless regions of virtual space. Animation programs, and many other types of interfaces are designed according to the goal of implementing constraints.

[213] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 253.

Consistent with a theory of intuitive design, constraints limit the manner in which models, characters, and objects can behave and react to one another. For instance, to make digital animation easier, some programs implement rules of kinetics into their skeletal or wire frame structures. In other words, the program will only let you proceed according to the logic of organic movement or in terms of real-world physiology. One *Maya* expert explains that creating an underlying bone structure in a character initiates a series of interdependent connections in other places on the skeleton. Using the example of coordinating the movements of the feet to the movements of the torso, he advises that readers utilize expression functions. "An expression function is a predefined command that can be used in an expression instead of explicitly writing the complicated math associated with the command."[214] Similiarly, one research paper describes its goal to "introduce a new system that uses constraints to restrict object motion in a 3-D scene, making interaction much simpler and more intuitive."[215] Constraints placed on 3D modeling automatically enable typical modeling sequences like meshes, patches, and texture mapping. At the same time however, these constraints can impose limitations on experts. Chris Maraffi advises that "sometimes you will want to disable these expressions and animate these motions manually."[216]

The encoding of real-world constraints provides a realistic context in which a digital character or object must function. Constraints are also influenced by a theory of ecosystems and other biological systems in the sense that the organism is both defined by and, in turn defines, the environment in which it is placed as it struggles to maintain equilibrium. Therefore, one way of obtaining realistic animations is to ensure that the user follows the laws of physics. Depending

[214] Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 150.
[215]Tim Salzman, Graham Smith, and Wolfgang Stuerzlinger, "3d Scene Manipulation with 2d Devices and Constraints" (paper presented at the Graphics Interface 2001, Ottawa, Ontario, 2001), p. 135.
[216] Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 150.

on the task, these constraints can make the animator's job much easier by restricting a bewildering assortment of potential actions and behaviors to those that only occur in the real world. At the same time, these constraints limit artistic possibilities in that they assume that animation should be guided by a precise correspondence to reality.

For example, a program designed to organize space architecturally in order to make models for commercial use benefit from real-world constraints. "In our system, information about how an object interacts with the physical world assists the user in placing and manipulating objects in virtual environments. Each object in a scene is given a set of rules, called constraints, which must be followed when the object is being manipulated."[217] In other words, people do not normally put ceiling lamps on the floor and couches do not usually hover in space. However, if the animator were using this program for artistic or narrative purposes, she may actually want to animate a couch spinning in mid-air with a confused elderly couple clinging to each other in terror as the roof of their house opens up to reveal a space craft that snaps them up with a tractor beam and whizzes away. The problem with pre-designed constraints is that they potentially limit the animator's freedom. Since interface design is largely a process of making a tool whose uses and ends are largely unknown, constraints represent yet one more way that digital technology solves some design problems while simultaneously creating new ones.

Another technique for solving the problem of accessibility is the integration of various forms of "shortcuts." *Maya* "plug-ins" are written by experts in order to guide novices through the dense jungle of the animation interface. Plug-ins are modifications of existing software that can be sold independently to other animators. "Plug-ins are third-party specialized mini-software applications that 'plug into' and enhance the capabilities of larger turnkey products."[218] Usually

[217] Salzman, "3d Scene Manipulation with 2d Devices and Constraints."
[218] Masson, *Cg 101: A Computer Graphics Industry Reference*, p. 378.

written by experts or even other companies, plug-ins are usually shortcuts designed to make sure that other users of the software don't have to "reinvent the wheel." For instance, once a particular code has been written for a lighting effect, it can be offered as a plug-in, thereby eliminating hours of laborious steps necessary to rediscover it. "For instance, Darktree Shaders . . . make excellent plug-ins for 3ds max, LightWave, C4D, Hash and True Space animation programs that enable you to zoom in on an object."[219] Plug-ins are a type of compromise between the goal of transparency and the goal of complexity.

The great difficulty in creating a usable animation interface, and to which *Maya*'s commercial success is attributable, is defined by the ability to maintain the complexity of the algorithms that underlie the operations, while at the same time, only affording limited access to the typical user. The deep structure of *Maya* is a computer language that can be altered and manipulated by experts. "Advanced users of *Maya* tend to employ MEL (*Maya* Embedded Language) in many ways, some of which become marketable plug-ins that advance the general capabilities of the program and can be offered to the community at large for profit or fame."[220] In a rapidly changing graphics environment driven by photo-realism, an interface that can accommodate unexpected requirements for digital design, is valuable. Once a program is written for a complex natural occurrence like melting, wafting, or reflecting, that program can be stored and used again and again in a variety of contexts. *Maya* is malleable enough to inspire professional animators to customize their own tools, rewrite certain operations, and even discover and write short cuts. However, one of the most challenging aspects of digital design is where to find the plug-in or database for a particular effect, rather than how to create it from the ground up.

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[219] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*., p. 252.
[220] Ibid., p. 213.

Another technique used within the human-computer interaction field is what is referred to as "smart" or "intelligent" user interfaces. For instance, one research paper explains an experiment with an interface that depicts an emotionally responsive human. "This paper presents a humanoid computer interface (Jeremiah) that is capable of extracting moving objects from a video stream and responding by directing the gaze of the animated head toward it. It further responds through change of expression reflecting the emotional state of the system as a response to stimuli . . . Jeremiah provides the first step to a new form of intuitive computer interface."[221] The operant design metaphor (and a highly anthropomorphized one) is that the computer is a patient and helpful assistant, i.e., a human. According to one author, "pretending the system is human is a powerful tool at the interaction-level appropriate to key path scenarios. The principle is simple . . . Interactions with a digital system should be similar in tone and helpfulness to interactions with a polite, considerate human."[222] The human metaphor is clearly a way to ease beginner anxiety but the metaphor holds for experts and professionals as well. One paper tries to inculcate friendly gestures within the software. "Communicative behaviors such as salutations and farewells, conversational turn-taking with interruptions, and referring to objects using pointing gestures are examples of protocols that all native speakers of a language already know how to perform and that can thus be leveraged in an intelligent interface."[223] Presumably, a computer that behaves like a human will make users more comfortable in learning and mastering complex tasks.

[221] Richard Bowden, Pakorn Kaewtrakulpong, and Martin Lewin, "Jeremiah: The Face of Computer Vision" (paper presented at the ACM International Conference Proceeding Series, Hawthorne, NY, 2002), p. 124.
[222] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 87.
[223] J. Cassell T. Bickmore, H. Vilhjalmsson, and H. Yan, "More Than Just a Pretty Face: Affordances of Embodiment" (paper presented at the International Conference on Intelligent User Interfaces, New Orleans, LA, 2000), p. 52.

Among the long list of human-like attributes that an interface should convey are consideration, helpfulness, doing no harm (interpersonal, psychological, physical, or social), increase understanding, efficiency, improve communication, reduce socio-cultural tensions, and foster equity and cultural diversity. Further, the interface should be purposeful, pragmatic, elegant, accommodating, and polite.[224] In addition, software should "take an interest," "is deferential," "uses common sense," "anticipates needs," is "conscientious," "doesn't burden you with its personal problems," is "perceptive," and "self-confident."[225] It fails gracefully, isn't stingy with information, doesn't ask a lot of questions, knows when to bend the rules, and takes responsibility. Similarly, Mandel uses terms like, "encouraging," "forgiving," and "enticing" to describe the characteristics of the interface. One can imagine that this comprehensive array of noble qualities would be difficult to implement, especially since the humans designing the interface probably, along with the rest of us, cannot live up to such stellar attributes.

An example of non-user centered design or unfriendly computer behavior are boxes that pop up when the user is trying to perform a familiar or new task that bark at and blame the user like "error," "default," "action not allowed," "file is blocked" and so on. These are considered to be very rude computers. One reason that designers anthropomorphize the interface is because usability testing presents an image of users as impatient, domineering, and unwilling to admit their own mistakes. However, Mandel also observes that casting the computer as a living entity with feelings can sometimes instantiate tension in the design process by affording opportunities for human traits like dominance and impatience.

With all of this attention on the characteristics of humans and computers, it is easy to see how the interface design process might instantiate social inequity. In a sense, the human and the

[224] Reimann, *About Face 2.0: The Essentials of Interaction Design*, pp. 95-98.
[225] Ibid., pp. 183-184.

computer become enemies because of their different ways of doing and thinking. Mandel presciently observes that "most of the hard-edged rules enforced by computer systems are imposed to prevent just such mistakes. These inflexible rules cast the human and software as adversaries, and because the human is prevented from fudging to prevent big mistakes, he soon stops caring about protecting the software from really colossal problems."[226] Despite all this attention to the humane interface however, Mandel urges that you only really have to "let users think they are in control."[227] Design theory and usability testing is fraught with this subtle charge that computers are smart and humans are dumb. This relationship does not naturally or magically exist between human and computer. Rather, it is part of the design of the software. The problem, of course, is that we don't necessarily want the tools that we use to accomplish a variety of tasks to hail us as if they were alive. Most people have enough problems maintaining human relationships without adding another, albeit more mechanical one, to feel guilty about. Many users would prefer a functional system that doesn't pester us with questions and suggestions but behaves more like a microwave or other household appliance, by simply doing what it is told to do.

The process of interface design is not a matter of building a static representation, but a matter of creating a life form that exhibits certain behaviors.

> The look and behavior of your program should reflect how it is used, rather than an arbitrary standard. A program's behavioral stance—the way it presents itself to the user—is its posture. The look and feel of your program from the perspective of posture is not an aesthetic choice: It is a behavioral choice. Your program's posture is its behavioral foundation, and whatever aesthetic choices you make should be in harmony with this posture.[228]

[226] Ibid., p. 189.
[227] Mandel, *The Elements of User Interface Design*, p. 189.
[228] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 103.

Strangely, however, the authors conclude that people don't want to interact with an interface in the manner they would with a human. "Many developers imagine the ideal interface to be a two-way conversation with the user. However, most users don't see it that way. Most users would rather interact with software in the same way they interact with, say, their cars."[229] This observation underscores one tension within the design community. Designers do not always agree whether the human-communication model or the mechanical-pragmatic model will bring about greater ease of use. As we will see, this is just one of several ideological, material, and conceptual dichotomies that permeate the field of interface design.

One area of research that interface designers devote a lot of attention to is in pointing and navigating devices. The physical manner in which the user interacts with the interface falls under the category of tangible user interfaces.[230] The great breakthrough in designing computers for personal use was the creation of a mouse that functioned as a hand to push buttons that represent certain processes and objects. Raskin argues that, "Increasingly, inventions have come to the aid of intellectual rather than physical pursuits. We must master an ergonomics of the mind if we want to design interfaces that are likely to work well."[231] This statement underscores the fact that

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[229] Ibid., p. 120.

[230] Volkert Buchmann, Stephen Violich, Mark Billinghurst, and Andy Cockburn, "Fingartips: Gesture Based Direct Manipulation in Augmented Reality" (paper presented at the Computer Graphics and Interactive Techniques in Austalasia and South East Asia, Singapore, 2004), Angela Chang, Eric Gunther, Hiroshi Ishii, Rob Jacob, and Sile O'Modhrain, "Comtouch: Design of a Vibrotactile Communication Device" (paper presented at the Symposium on Designing Interactive Systems, London, England, 2002), Ian Creighton, and Chris Ho-Stuart, "A Sense of Touch in Online Sculpting" (paper presented at the Computer Graphics and Interactive Techniques in Austalasia and South East Asia, Singapore, 2004), Marissa Diaz, and Isaac Rudomin, "Object, Function, Action for Tangible Interface Design" (paper presented at the Computer Graphics and Interactive Techniques in Austalasia and South East Asia, Singapore, 2004), Jodi Forlizzi, and Shannon Ford, "The Building Blocks of Experience: An Early Framework for Interaction Designers" (paper presented at the Symposium on Designing Interactive Systems, New York, NY, 2000), Jared Go, James J. Kuffner, and Thuc Vu, "Autonomous Behaviors for Interactive Vehicle Animations" (paper presented at the Symposium on Computer Animation, Grenoble, France, 2004), David McGee, and Philip R. Cohen, "Creating Tangible Interfaces by Augmenting Physical Objects with Multimodal Language" (paper presented at the International Conference on Intelligent User Interfaces, Santa Fe, NM, 2001), Dag and William Verplank Svanaes, "In Search of Metaphors for Tangible User Interfaces" (paper presented at the Designing Augmented Reality Environments, Elsinore, Denmark, 2000), Liz C. Throop, "Field of Play: Sensual Interface" (paper presented at the Designing Pleasurable Products and Interfaces, Pittsburgh, PA, 2003).

[231] Raskin, *The Humane Interface: New Directions for Designing Interactive Systems*, p. 10.

physical and mental understandings of space are collapsed when it comes to the activities of real users. In other words, most of the operations conducted in virtual space using an interface assume a co-presence of body and mind. Operations are rarely purely ergonomic or intuitive, rather cognitive and physical models operate in tandem just as they do in the 'real' world.

Designing interfaces that afford direct manipulation of objects in virtual space is considered to be a step toward making software more intuitive. One designer explains that

> Placing shadows is a difficult task since shadows depend on the relative positions of lights and objects in an unintuitive manner. To simplify the task of the modeler, we present a user interface for designing shadows in 3D environments. In our interface, shadows are treated as first-class modeling primitives just like objects and lights. To transform a shadow, the user can simply move, rescale or rotate the shadow as if it was a 2D object on the scene's surfaces.[232]

Rather than tweaking complex algorithms to render light effects, this interface promises a more direct relationship with physical attributes. Theo Mandel urges interface designers to, "wherever possible, encourage users to directly interact with things on the screen, rather than using indirect methods, such as typing commands or selecting from menus. While you still must allow for both keyboard and mouse navigation and selection, you should optimize the interface toward users' most natural interaction style."[233] Tangibility is interconnected with the use of real-world design metaphors, since these metaphors allow users to interact with objects and operations in cyberspace as they would in "meatspace."

An early example of tangible user interface design was the Macintosh desktop operating system. The global metaphor used in this instance was typical office equipment. The now familiar design includes objects that one can interact with such as phones, file folders, trash bins,

[232] Donald P Greenberg, Fabio Pellacini, and Parag Tole, "A User Interface for Interactive Cinematic Shadow Design" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, San Antonio, TX, 2002), p. 563.
[233] Mandel, *The Elements of User Interface Design*, p. 61.

briefcases, and paintbrushes. Another example of tangible design is Adobe Acrobat's transformation of the cursor into a tiny virtual hand that clutches and grasps at pages. Designers, particularly those of augmented reality in which the interface becomes indistinguishable from a real object like a book or even a plant, complain that the cultural conventions of screen, keyboard, and mouse are obstacles to achieving maximum intuitive interaction. One paper experiments with the possibility of using a foot pedal to produce digitally animated scenes and characters. Much tangible interface design is an attempt to harmonize with embodied common-sense actions of the user rather than to produce logical, cognitive processes. "We present an intuitive animation interface that uses a foot pressure sensor pad to interactively control avatars for video games, virtual reality, and low-cost performance-driven animation . . . Our system thus makes it possible to create interactive animations without the cost or inconveniences of a full body motion capture system."[234]

Another example of tangible interface design explores a technique using a head mounted display and a wand to create digital objects.

> This article describes HoloSketch, a virtual reality-based 3D geometry creation and manipulation tool. HoloSketch is aimed at providing nonprogrammers with an easy-to-use 3D 'What-you-see-is-what-you-get' environment. Using head-tracked stereo shutter glasses and a desktop CRT display configuration, virtual objects can be created with a 3D wand manipulator directly in front of the user, at very high accuracy and much more rapidly than with traditional 3D drawing systems.[235]

The WYSIWYG (what-you-see-is-what-you-get) environment signals an approach to intuitive interface design such that all of the controls and tools are placed before the user at once.

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[234] Kang Kang Yin, and Dinesh K. Pai, "Footsee: An Interactive Animation System" (paper presented at the Symposium on Computer Animation, San Diego, CA, 2003), p. 329.
[235] Michael F. Deering, "Holosketch: A Virtual Reality Sketching/Animation Tool," *ACM Transactions on Computer-Human Interaction (TOCHI)* 2, no. 3 (1995), p. 220.

Another example of tangibility, although not a graphics interface, occurs in an experiment in communication based on both voice and touch for bodies at a distance from each other. "We describe the design of ComTouch, a device that augments remote voice communication with touch, by converting hand pressure into vibrational intensity between users in real-time. The goal of this work is to enrich interpersonal communication by complementing voice with a tactile channel."[236] Another technique that has garnered some attention from designers is the use of what is called "virtual clay." Given the properties of 3D graphics, it makes more sense to base virtual graphics on sculpting than on drawing or film since, indeed, animators are tackling issues like volume, weight, shape, and surface texture in their digitally-rendered scenes. One such experiment with virtual clay called "Kizamu" explains that it is a "computer-based sculpting system for creating digital characters for the entertainment industry . . . First, animators and artists want digital clay—a medium with the characteristics of real clay and the advantages of being digital."[237] Yet, another paper explores the possibility of transforming the human body into "a dynamic brush." The authors explain that they "introduce a novel approach to create complex scenes involving thousands of animated individuals in a simple and intuitive way. By employing a brush metaphor, analogous to the tools used in image manipulation programs, we can distribute, modify and control crowd members in real-time with immediate visual feedback."[238] Further, "In this paper, we will present an approach to design a more natural user interface without taking resort to special haptic input/output devices. Tactile sensations like stickiness, touch, or mass can be evoked by applying tiny displacements upon cursor

[236] Chang, "Comtouch: Design of a Vibrotactile Communication Device," p. 312.
[237] Sarah F. Frisken, and Ronald N. Perry, "Kizamu: A System for Sculpting Digital Characters" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 2001), p. 47.
[238] Pablo de Heras Ciechomski, Daniel Thalmann, Branislaw Ulicny, "Crowdbrush: Interactive Authoring of Real-Time Crowd Scenes" (paper presented at the Symposium on Computer Animation, Grenoble, France, 2004), p. 243.

movements."[239] The Body-Brush project speaks directly to a key issue in interface design, the human body.

Whether it is figured as an asset or an obstacle to interactions with the computer, the body of the user is an ever-present element that guides design in crucial ways. Collectively, each of these papers articulate ways of interacting with an interface that bypass the conventions of the keyboard, the mouse, and the screen. But what is most interesting about these examples is that some of them define new ways of interacting with virtual tools rather than simply borrowing from older cultural forms. For instance, we don't think of traditional methods of drawing as involving either the entire body or the feet. These projects temper claims made by Lev Manovich and Bolter and Grusin that new media forms borrow conventions from prior cultural forms like film and drawing. In fact, film, drawing, and special effects conventions do comprise global metaphors in most animation programs. However, increasingly, these are considered to be obstacles that hold back innovative new approaches. For instance, Raskin would argue that these are unnecessary "mechanical age" functions that have worn out their welcome. Recall that thinking about the body of the user is motivated by the goal of making the graphics interface easier to use. David Em underscores that the usefulness of tangible user interface lies in its ability to bypass all of the complex procedures normally involved in digital animation. Em raves about a new software system for 3D design, Amorphium, showcased at SIGGRAPH,

> While today's high-end 3D packages can model everything from skyscrapers to Godzilla, being productive with them usually requires learning complex techniques such as creating Bezier curves in 3D space, selecting and manipulating vertex selection sets and subsets and other arcane(a). These nonintuitive design processes have kept both professional sculptors and interested amateurs intimidated at worst and frustrated at best. The answer is

[239]Koert van Mensvoort, "What You See Is What You Feel: Exploiting the Dominance of the Visual over the Haptic Domain to Simulate Force-Feedback with Cursor Displacements" (paper presented at the Symposium on Designing Interactive Systems, London, England, 2002), p. 345.

> 'haptics'—a sense of pushing and pulling a virtual 3-D model—term for 'force-feedback' . . . meaning you can sense resistance when you move around an input device such as a joystick.[240]

The author identifies the complexity and limitations of traditional animation interfaces, especially for novices, and extols the virtues of a sculpting system that involves a 'real' sense of pressure and direct manipulation.

Most interface design is often unconsciously motivated by either an emphasis on the user's cognitive model or an emphasis on his or her physical presence. Tangible user interface design is intertwined with the presence of the human body, in addition to the human mind. In other words, humans often do not approach digital tools logically, but sensually and experientially. They are feeling creatures that exist simultaneously in virtual space and real space. For example, tangible user interface design is clearly preoccupied with the body of the user, while the grammar of icons and metaphors appeals to memory, learning, inference, and visual thinking. The discrepancy between the attributes of the body and attributes of the mind forms an aporia within the field.

Before I discuss how the relationship between the mind and body is instantiated in the design of cultural interfaces, I will gather the design goals that I have discussed under the concept of transparency. Whether or not the focus is on tangible user interfaces or intuitive interfaces, the ideal goal is always to get the user to forget that the interface is there. Theo Mandel chides designers to consider that "A user interface is an artifact, not directly related to the goals of the user. Next time you find yourself crowing about what cool interaction you've designed, just remember that the ultimate user interface for most purposes is no interface at all."[241] Mandel uses the term "facilitative" synonymously with transparency. He states that "The

[240] Em, "The Siggraph and Seybold Report."
[241] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 120.

secret of a transparent interface is being in synch with the user's mental model. Users should be free to focus on the work they are trying to perform, rather than translating their tasks into the functions that the software program provides."[242] The Origami Desk, for example,

> Uses projected video clips to show users how folds should be made, projected animations to directly map instructions onto the users' paper, electric field sensing to detect touch inputs on the desk surface, and swept-frequency sensors to detect the papers folds . . . More importantly, the Origami Desk project incorporated numerous aspects of design—hardware design, installation design, interface design, graphic design, sensor design, software design, content design—into an interactive experience aimed at making the user forget about the technology altogether.[243]

As argued by Bolter and Grusin, hypermedia or the piling up of text upon text, technology upon technology, is ironically, supposed to produce transparency. One wonders however, how the Origami Desk's combination of "numerous aspects of design" in addition to different virtual tools, can make a user forget about its presence. If anything, hypermedia calls attention to the presence of technologies of mediation. One researcher complains about his tangible user interface project by stating that "the problem with all these approaches, when used in the front of the large screen, is the learning curve, since they don't mirror any familiar 'interface' from the real world for the regular users and/or obstructiveness, e.g., full body motion capture requires many sensors attached to the user."[244]

Within the industry, the concept of "flow" refers to the phenomenon of being so engaged and focused on a particular task that one loses a sense of time and physical context. Designers seek to implement techniques within interface design that will aid this process. According to Cooper and Reimann, "to create flow, our interaction with software must become transparent. In

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[242] Mandel, *The Elements of User Interface Design*, p. 61.
[243]Leonardo Bonanni, et al., "Origami Desk: Integrating Technological Innovation and Human-Centric Design" (paper presented at the Symposium on Designing Interactive Systems, London, England, 2002), p. 399.
[244] Jan Ciger, Mario Guiterrez, Frederic Vexo, and Daniel Thalmann, "The Magic Wand" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, Budmerice, Slovakia, 2003).

other words, the interface must not call attention to itself as a visual artifact, but must instead, at every turn, be at the service of the user."[245] As the above passage indicates, the interface is supposed to fade into the background as it mediates seamlessly between the needs of the human user and the operations of the computer. Recent convention papers demonstrate the design goal of collapsing the distance between computer operations and the human practitioner's body by rendering that relationship more 'natural' and reducing the presence of the hardware.[246]

It is not an exaggeration to claim that the interface is supposed to engage in a 'disappearing' act. Not surprisingly, several experiments on interface design treat the 'magical' nature of the interface. This term functions as both a common metaphor and a concrete practice within the professional literature.

> A powerful tool in the early stages of developing scenarios is to *pretend the interface is magic* . . . Magical solutions obviously won't suffice, but figuring out creative ways to design interactions that are as close to magical solutions as possible (from the personas' perspective) is the essence of great interaction design. Products that meet goals with the minimum of hassle and intrusion seem almost magical to users.[247]

Theo Mandel argues that although design principles must adhere to technical principles, the end-product should offer itself as a seamless tool, which he equates with magic. But his definition of a magical interface is consistent with the goals of transparency. In an otherwise sober guide to interface design, Mandel evokes the magical properties of the interface by claiming that, "The user interface is the mystical, mythical part of a software product. If done well, users aren't even aware of it. If done poorly, users can't get past it to effectively use the product. A goal of the

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[245] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 120.
[246] Buchmann, "Fingartips: Gesture Based Direct Manipulation in Augmented Reality," Thomas Pederson, "Human Hands as a Link between Physical and Virtual" (paper presented at the Designing Augmented Reality Environments, Elsinore, Denmark, 2000), Jeffrey S. Pierce, Brian C. Stearns, and Randy Pausch, "Voodoo Dolls: Seamless Interaction at Multiple Scales in Virtual Environments" (paper presented at the Symposium on Interactive 3D Graphics, Atlanta, GA, 1999).
[247] Reimann, *About Face 2.0: The Essentials of Interaction Design*.n, p. 82.

interface is to help users feel like they are reaching right through the computer and directly manipulating the objects they are working with."[248]

As early as 1973 and through to 2003, designers have commented on the efficacy of the magic metaphor, finding crucial aspects in both new and old media forms that closely mirror the goals of stage magic. One researcher finds the correspondence between computer technology and magic a bit "spooky." "Magicians have been designing and presenting illusions for 5000 years. They have developed principles, techniques and ethical positions for their craft that this paper argues are applicable to the design of human/computer interfaces. The author presents a number of specific examples from magic and discusses their counterparts in human interface design."[249] Yet another experiment involves changing the user into a "wizard."

> We want to present a multimodal user interface for interaction with the virtual environment back-projected on the large projection screen. We use the interaction metaphor of a 'spell-casting' wizard (the user) using a 'magic wand' to interact with the VR environment and to complete some tasks. Our contribution is a user interface, which tries to take advantage of the past experience of the user such as fairy-tales and fantasy movies.[250]

Within a handful of articles, the magic metaphor, however, is not limited to the users experience. Some argue that designers are themselves either plagued or inspired (depending on who you consult) by magical thinking. "Because of the high rate of turnover in many computer installations, and the reluctance to alter existing software, many routine programs have never been examined by anyone in the installation. They may work, but no one really knows 'how they work'—ritual magic."[251] Although, writing in 1973 the author considers this type of thinking to

[248] Mandel, *The Elements of User Interface Design*, p. 60.
[249] Bruce Tognazzni, "Principles, Techniques, and Ethics of Stage Magic and Their Application to Human Interface Design" (paper presented at the Human Factors in Computing Systems, Amsterdam, The Netherlands, 1993), p. 355.
[250] Ciger, "The Magic Wand."
[251] David Freedman, "Computer Magic" (paper presented at the Special Interest Group on Computer Personnel Research, College Park, MD, 1973).

be a detriment in the field that potentially stalls technological innovation, he nevertheless seized upon an idea that others would take up with enthusiasm years later.

One of the problems associated with magical design is that it does not necessarily fit the standard definition of intuitive design since, metaphors are supposed to be familiar while magic is probably not something that a typical user experiences in their day-to-day world.

> Most research on metaphors and computers focus on the augmentative power of the similarity between the computer application and something already familiar to the user. But metaphor may play two fundamentally different roles depending on whether the primary role of the metaphor is to express something by building on the similarity between the two referents or whether the primary role is to express something new by emphasizing dissimilarities.[252]

Following the critiques of metaphor mentioned earlier in this chapter, this researcher suggests that theories of metaphor in interface design should not only emphasize what is known by the user but should also offer exciting and novel possibilities for interaction commensurate with new technological capabilities.

On the other hand, some posit that the magical interface is wholly consistent with intuition or operations that bypass the learning curve. The suggestion is that magical thinking is a natural way to interact with objects in the world. Further, user-focused design suggests that the use of magic as a metaphor renders interface platforms easier to use.

> If the user could achieve his goals magically, without your program, he would. By the same token, if the user needed the program but could achieve his goals without going through its user interface, he would. Interacting with software is not an aesthetic experience (except perhaps in games, entertainment, and exploration-oriented interactive systems). For the most part, it is a pragmatic exercise that is best kept to a minimum.[253]

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[252] Eric A. Bier, et al., "Toolglass and Magic Lenses: The See-through Interface" (paper presented at the International Conference on Computer Graphics and Interactive Techniques, 1993).
[253] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 119.

In other words, the magic metaphor is not easily housed under the definition of intuition (at least not in the sense that this term is used in the field as learned or familiar actions).

In 1986, interface designers were experimenting with magic as a design metaphor. For example, "The Alternate Reality Kit" functioned as a test case for beginners. The goal was to have relatively inexperienced computer users sit down and quickly learn to master an interface designed around 'real world' iconography. A hand represented the subject's hand and this hand could be used to initiate a number of actions such as turning on a light switch.

> All objects have a visual image, a position, a velocity, and can experience forces. One of the objects is a hand, which the user controls with a mouse. With the hand, the user can carry objects, throw them, press buttons and operate slider controls . . . The intent is to have the user conclude very quickly that the screen depicts a physical world, and that the user is directly manipulating physical objects.[254]

The ultimate goal of the program was to find out how long it took users to figure out that some of rules in the program could be broken. The investigator defines these parameters as 'literal' versus 'magical' features of the interface. Literal features are those that are true to the design of the interface (for instance, one would expect to be able to turn a virtual light switch on and off with a virtual hand since such behavior is consistent with real-world operations). Magical features, on the other hand, are described as "enhanced capabilities at the price of breaking out of the metaphor. These features might allow the user to do wonderful things that are far beyond the capabilities of the literal features."[255] An instance of magical features include such things has hidden doors and the discovery of embedded pop-up information and objects. The tension between literal and magical features has recently been integrated with success in the design of

[254] Randall B. Smith, "Experiences with the Alternate Reality Kit: An Example of the Tension between Literalism and Magic" (paper presented at the Conference on Human Factors in Computing Systems, Toronto, Ontario, CA, 1986), p. 62.
[255] Ibid., p. 61.

video games whereby discovering the 'hidden' rules (and subsequently breaking them) has become a common element in playing a video game.

It is not surprising that a topic of profound theoretical, practical, historical, and cultural relevance would be treated ambiguously in the design literature. Even scholars of magic proper can seldom agree on what it is. The definition that emerges from these design projects, however, is remarkably consistent with scholarship that posits that there is no hard distinction between the history of science and technology and the history of magic. I believe that scholars of magic might be surprised to discover the great efficacy of the term within a high-tech field, let alone the fact that it is discussed at all.

The reason that magic has become such a powerful metaphor in industry parlance is that it is capable of referring simultaneously to body and mind. The cultural history of magic, like that of alchemical transmutation, does not recognize a distinction between the two and posits a reality in which mind and body are coextensive. In addition to iconography and alchemical symbolism, magical metaphors use pre-modern concepts and practices that are more appropriate models for the digital age. As this dissertation argues, contemporary digital technology drags us back, willingly or not, to a period of time prior to the Age of Reason, the Age of Science, and the Age of Industry; all of which signal the heyday of modern society. Simon During points out in his book on the cultural history of magic, that the art of illusion is deeply embedded in technologies of transformation. "Indeed, natural magic is never simply natural: it requires the intervention of human technique, if not to produce effects then to 'discover' them . . . Here marvels are produced by rare mechanical devices whose working is often hidden or not clearly understood: mirrors, lenses, optical apparatus materialized nature's occult qualities through

'experiments.'"[256] Magic and science share a close kinship in that both are artificial ways of manipulating and changing reality.

All of the techniques implemented by designers raise more problems than they solve. The "mystical" aspects of the interface are too amorphous and difficult to study, while the cognitive, logical, or linguistic aspects of using real-world metaphors and elaborate icons can likewise be confusing, or even restricting. The main problem with interface design is that engineers of software are uncertain as to which is more crucial to the user, rational thought or embodied behavior. Of course, both of the aspects of engagement are important, and further, both must be learned. However, it is the unacknowledged, but lingering belief that the mind and body represent separate modes of interaction within a realm in which they are actually fused, that causes difficulties within the literature. The main obstacle to interface design is the incommensurate juxtaposition of tangibility and transparency.

The real goal of interface design is transcendence of the body and mind. But the problem is that the main techniques of interface design either consciously hail their features, thus calling attention to the "objects" on the screen, or they seek to make them fade away into the background, merely allowing the operator to use the interface to accomplish his or her task and forget about the technology. The problem is that having lots of icons and objects to interact with often gets in the way of the design goal of transparency. "One of the main criticisms leveled at graphical user interfaces by experienced computer users . . . is that getting to where you want to go is made slower and more difficult by the extra effort that goes into manipulating windows and icons. Users complain that, with a command line, they can just type in the desired command and

[256] Simon During, *Modern Enchantments: The Cultural Power of Secular Magic* (Cambridge, MA: Harvard University Press, 2002), p. 19.

the computer executes it immediately."[257] Using the intuitive model is often a clunkier and slower route for professionals who know their way around a computer, i.e., who know programming language.

> Especially as the graphics capabilities of color screens increase, it is tempting to render icons and visuals with ever-increasing detail, producing an almost photographic quality. However, this trend does not ultimately serve user goals, especially in productivity applications . . . Although such icons may look great, they draw undue attention to themselves and render poorly at small sizes, meaning that they must necessarily take up extra real estate to be legible. They also encourage a lack of visual cohesion in the interface because only a small number of functions (mostly those related to hardware) can be adequately represented with such concrete photo-realistic images.[258]

Designers are unclear as to whether transparency is created through sensuous embodied contact with digital tools and objects or whether it is a 'state of mind' whereby one is concentrating on their work to the extent that the interface is not noticeable, and therefore, precisely not a tangible object.

Another problem raised during the design process is the issue of how to conceptualize the relationship between the user and the computer. Quite often, designers inadvertently pit computer against human, or expert against novice. Theo Mandel observes that users will engage in "superstitious" behavior if their expectations of what a particular operation should do are violated. "Poor product interface designs often lead users to doubt their interaction strategies and develop strange and superstitious behaviors to account for illogical and inconsistent system design."[259] The example he provides is continually restarting the computer when the user perceives that it has "frozen" whether it actually has or has not. He blames the behaviors on inconsistent design but he is also clearly crafting a particular user persona of impatience and

[257] Reimann, *About Face 2.0: The Essentials of Interaction Design*, p. 136.
[258] Ibid., p. 235.
[259] Mandel, *The Elements of User Interface Design*, p. 25.

ignorance. "Keep interaction results the same—If users experience different results from the same action, they tend to question their own behavior rather than the product's behavior. This leads to users developing superstitious behavior, that is, they think they must do things in exactly a certain way for the desired result to happen, otherwise they are not sure of the results."[260]

There is a discrepancy in the literature about the functions of the body and the mind. We think through doing things and vice versa. A good example of this occurs in writing practices. Prior to the advent of word processing, individuals who were accustomed to write and therefore think, via a pen and paper, had a difficult time converting to the keyboard. The reverse is also true. When new media scholars talk about the disembodying aspects of virtual reality, they are usually referring to the process of interacting with an interface. In other words, whether the interaction is transparent or tangible, they are nonetheless using a cultural artifact that shapes their experiences in virtual space. Issues of identity construction, the relationship between mind and matter, and numerous other issues both social and subjective, revolve around this confrontation with a computer screen, head mounted display, or other types of augmented realities.

However, many speculations concerning the problem of the body and technology avoid a forthright analysis of the material reality of the screen and its metaphysical implications for the human user's body. Producers and designers of interfaces, as I have shown above, are constantly thinking about the demands and the limitations of both the body and mind of the end-user when attempting to communicate with a computer. This is evident in the design of interfaces used in animation as well as in the goal of real-time animation in the gaming industry which lauds the goal of interactivity. The goal of the process is transcendence. First, the issue of transcendence can be understood as the goal of achieving a seamless union between the interface and the body

[260] Ibid., p. 77.

and mind of the user. In an important sense, interface design seeks to bypass the body. A good fictional example of this is the film *Minority Report* in which the main character uses a holographic projection of an interface that can be directly manipulated with hands (albeit using a dataglove). No keyboard. No mouse. Metaphysically, the interface links two incommensurate realms—the human body with the virtual space of the computer. One of the obstacles to transcending the body for both animators and interface designers is the incommensurable relationship between computer language and human language. The interface is designed to function as a bridge for interaction between human and machine. In animation software design, the interface is the zone where the human body and mind comes into contact with the technological apparatus that will assist the human in animating inert objects. It is taken for granted that the human body is an obstacle to achieving this end. Interface design past and present is continually motivated by the question of how to make the interface more ergonomic or friendly to the human body and more intuitive or friendly to the human mind. The problem of what to do with the excess, is a problem of embodiment, since the excess represents, simultaneously, the dross that congeals around the object and the "flesh" of the practitioner. The body is often configured as cumbersome compared to the abstract language of the computer. The body requires all kinds of complex gear in order to enter the virtual realm. The point is that the conventions that govern interaction with cultural artifacts are instantiated in the technological artifact itself. Instead of less stuff, which would seem to harmonize with the goal of transparency and transcendence, we have a piling up of icons, operations, and material tools.

One obstacle to design is the mutability of the interface. Since it is a tool designed to accomplish unforeseen ends, it is very difficult to design that kind of flexibility into the interface. Interestingly, the ability to break rules and by extension, get the computer to think more like an

adaptable human, must be designed into the system itself. Interfaces do not serve us well if they are too perfect, and as such too rigid. We can think of an interface materially as a physical screen, and culturally as a symbolic exchange between computer and human, but it is more useful to theorize how these separate states are actually intertwined—in the sense that cultural contexts impact and are contained materially in the screen. The screen is a type of portal or passage-way that troubles the mind/body distinction because it really functions as a vehicle for both. In a very real sense, the user exists in two spaces simultaneously—the real and the virtual. This is the source of much speculation about whether or not digital media reconstitute our conception of reality.[261]

Like Chapter 1, this chapter reviews the actual practices and goals of interface designers. As in the quest for realism in digital animation, interface design is driven by a desire to transcend the body in terms of its incommensurate relationship to the machinery it confronts. Designers are constantly looking for ways to get the user to forget that the interface is there by achieving greater transparency and hence, direct access to virtual worlds. We find, however, that this is also a receding goal. Likewise, the attempt to bypass the body of the user in order to encourage a more 'natural' experience of the computer interface produces the residual effects of the designers material practices. By trying to balance the twin goals of accessibility and malleability, the resulting product (the interface) often piles layer upon layer of assorted commands represented by a complex iconic system. As a result, the desire for interface transparency is compromised. As we will see in the following chapter on alchemical transmutation, the process of attempting to transcend the physical recalcitrance of material body produces more residue rather than less.

[261] Ibid., p. 104.

4.0 CHAPTER 3
LIVING METALS: TECHCHINQUES OF TRANSMUTATION IN THE PARACELSIAN CORPUS

This chapter begins with an explanation of how alchemy functions as a mode of representation. In particular, this section will explore the collapse of metaphor and practice exemplified in the Paracelsian corpus. Scholars of Paracelsus within the field of the history and philosophy of science describe his achievements in a manner consistent with the goals of Enlightenment science. Therefore, the animistic and NeoPlatonistic qualities of Paracelsusian thought are sometimes downplayed or justified in light of his valid contributions to objective experimentation uncluttered by magical and spiritual influences. Paracelsus is usually celebrated for his approach to diseases and his attempt to demolish the old 'humoral' system.[262] Unfortunately, "while the observations and achievements in medicine and chemistry cited may be regarded as stepping-stones to modern science, it must be realized that they are selected from the larger body of Paracelsus' writings, which, in their totality, evoke a world of *magia naturalis* far removed from the modern spirit of independent inquiry."[263]

My use of Paracelsus is motivated, not by his contributions to science, but by the anti-enlightenment views he held that were characteristic of many natural philosophers during the Renaissance. In other words, I am interested in those aspects of his philosophy and methodology

[262] Charles Coulston Gillispie, ed., *Paracelsus*, vol. X, *Dictionary of Scientific Biography* (New York: Charles Scribner's Sons, 1974). The view that diseases were caused by an excess of one or another type of humor and thus, could be cured through purging, existed for many years prior to Paracelsus attempt to argue that disease itself was caused by a foreign substance that took possession of the body. Thus, therefore treatment should be directed at the agent of disease in particular.
[263] Ibid., p. 308.

that are dismissed on the grounds that these views are shrouded in medieval spiritualism. For the purposes of this work, however, these views represent a cache of cultural understandings about materiality and reality. For instance,

> Paracelsus believed that these [spiritual forces that make bodies act] achieved their purpose through what he called 'knowledge,' which is not of the observer but rather of the object observed . . . Knowledge therefore lies in the object itself and in its specific function; man can acquire this knowledge only through union with the object . . . Knowledge through union with the object is possible to man because all the substances and objects of the ambient world are somewhere and somehow represented in him.[264]

Paracelsus' theory of the co-extension of mind and matter is particularly useful to an analysis of contemporary theories of digital design not just because it offers us a pre-Cartesian ontology, but because it clarifies an important element of cultural continuity that is resurrected in contemporary media artifacts. The worldview to which Paracelsus ascribed, has not disappeared but as reemerged in a theoretical and material re-constellation within new media technologies.

I use Paracelsian alchemical texts as a means of understanding why contemporary theories of new media technology can't help but engage in metaphysical speculations on the nature of embodiment. I suggest in this chapter that the relationship between embodiment and immortality is brought into sharp focus through the lens of an alchemical worldview. Why do contemporary discussions of new media technology invoke the metaphysics of presence and issues of embodiment? One explanation lies in the mechanics and procedures for the artificial manipulation of matter as practiced and theorized by the alchemists for many centuries. I begin with an analysis of alchemy's artificiality; its concerns with temporal acceleration, processes for catalyzing change, and the animation of inert substances. I then describe Paracelsus' seven stages of alchemical transmutation, showing that transmutation is essentially, a process of separating

[264] Ibid., p. 308.

pure material from the impure material. One substance is divided into two over and over again. Each time two things are generated: a valuable essence and useless waste. All of the procedures taking place in the alchemist's vessel partake in a corresponding 'reality' within the alchemist's body. Therefore, procedures for the transmutation of metals, likewise conjure long-term cultural issues concerning the status of the flesh and its mortification and surrender for the sake of 'higher' goals.

Within the context of alchemy, the goal is to refine the relationship between essence and waste or soul and body. Therefore, the alchemist does not transcend the body, the alchemist transforms the body. Central to alchemical lore, is that the body can never be entirely left behind through the pure transcendence of the spirit. The alchemist is faced with matter's resistance to purification when he finds himself in the curious position of having more, rather than less matter when the procedures for transmutation are completed. Therefore, the presence of metaphysical speculation in new media literature can be explained in terms of the cultural history of the role of representation itself. The artificial copy is not a mirror image of the natural and/or biological original. The connection between the enduring co-presence of embodiment and materiality and technological augmentation revolves around the question of whether or not our procedures for transforming one thing into another thing is an accurate copy of natural law, or a monstrous deformity of natural law. The promise of technological augmentation is that the limitations of the body might be overcome, but we find that procedures for rendering and separating flesh and spirit, always seem to arrive just short of that goal. What the alchemists state simply in theory, that one need only extract and purify the unchanging essence of a thing, proves to be an illusive objective in practice. The theoretical problem raised by these procedures strikes to the core of the nature of artificiality itself. In the process of successive refinements, alchemical transmutation

generates waste. It is unclear, whether or not this 'residue' is the goal or essence of the work, or whether it is something to be cast onto the trash heap. These issues are pivotal to understanding the cultural consequences of fabricating the artificial of which digital and virtual modeling is a primary contemporary example.

Both serious scholars and casual observers of alchemy, both past and present, treat it as a metaphor. For many communication scholars, this metaphor serves as a stylistic flourish that refers, vaguely, to a process of ideological or psychological transformation. For example, in their well-known book on advertising, Goldman and Papson discuss the way in which an advertising campaign appropriates provocative cultural themes to its images through a process of alchemy. "Through the process of advertising alchemy Benetton turns these advertising taboos into a sign that represents difference."[265] In addition, William Covino, a scholar of rhetoric and literacy, poses that "We perform literate alchemy by presuming that a plurality of relationships and articulations may affect the transmutation of any 'pure' substance, fact, idea, or condition."[266] Scholars whose ostensible goal is the study of alchemy itself, however, also tend to downplay alchemy as a material practice in favor of what these practices signal on a psychological level.[267] In short, many have found that alchemy provides a useful set of terms to describe virtually any physical, psychological, and spiritual process that involves the transformation of one thing or state into another thing or state.

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[265] Robert Goldman, and Stephen Papson, *Sign Wars: The Cluttered Landscape of Advertising* (New York: The Guilford Press, 1996), p.120.

[266] William Covino, "Alchemizing the History of Rhetoric," in *Writing Histories of Rhetoric*, ed. Victor Vitanza (Carbondale: Southern Illinois University Press, 1994). and William Covino, *Magic, Rhetoric, and Literacy: An Eccentric History of the Composing Imagination* (Albany: State University of New York Press, 1994). p. 28.

[267] Titus Burckhardt, *Alchemy: Science of the Cosmos, Science of the Soul*, trans. William Stoddart (Baltimore, MD: Penguin Books, Inc., 1971; reprint, English translation first published: Vincent Stuart and John M. Watkins Ltd., 1967.), C. G. Jung, *Psychology and Alchemy*, trans. R. F. C. Hull, 2nd ed., *Bollingen Series Xx* (Princeton, NJ: Princeton University Press, 1968).

Alchemical metaphors are likewise used with remarkable consistency in new media technology literature. The difference for these writers, however, is that within the context of media technology, alchemy's emphasis on embodied, practical application finds renewed expression and applicability. In short, alchemical metaphors are used today to describe a process that catalyzes chemical decomposition, recombination, and the 'magical' transformation of material properties. However, despite the pervasiveness and conceptual efficacy of alchemical metaphors, alchemy is still often denigrated as a fossil science. This denigration occurs implicitly in a pervasive cultural and intellectual association with alchemy as a failed attempt to turn base metal into gold. But alchemy is also explicitly maligned in some histories of science, as the following passage from a textbook implies.

> The alchemist can be excused for not achieving the transmutation of metals, for this is still considered impossible by the means at his disposal. But one is astonished at the scale and duration of the effort. One is also astonished at the narrowness of the objective. The glitter of gold made it impossible for him to be objective, and if disinterested research is though to be a characteristic of the scientist, then the alchemist was no scientist. [268]

This passage shows that alchemy is considered a failure by today's scientific standards. Based on the standards of experimentation and objectivity, the author is puzzled as to why it endured for hundreds of years and may be surprised to learn that it garnered the avid adherence of respectable personages like Sir Isaac Newton.[269] Therefore, alchemy, defined empirically as the pursuit of gold, was a failure.

In another history of science textbook, alchemy merits no more than a paragraph of explanation, despite the fact that it endured for many millennia; perhaps dating back as early as

[268] Robert P. Multhauf, "The Science of Matter," in *Science in the Middle Ages*, ed. David C. Lindberg (Chicago: The University of Chicago Press, 1978), p. 380.
[269] Betty Jo Teeter Dobbs, *The Janus Face of Genius: The Role of Alchemy in Newton's Thought* (Cambridge: Cambridge University Press, 1991).

the sixth century B.C. with the rise of the craft of metallurgy.[270] Lindberg claims that alchemy is "one of the least studied and most poorly understood of all aspects of medieval science."[271] However, this is not precisely true, since an entire scholarly journal is dedicated to the study of alchemy.[272] *Ambix* dates back to 1937 and is still thriving today. Its editorial board includes such leading scholars in the field of history of science as Lynn Thorndike.

The authors of the preceding passages are perhaps innocent of alchemy's stunning success on other conceptual platforms since they are only concerned with alchemy as a scientific practice. When alchemy is considered in terms of its material practices (rather than its more spiritual or psychological ones), it is relegated to the status of pseudo-science. However, alchemy is very successful as a system of representation meant to symbolize the inner workings of the human psyche. The current use of alchemical metaphors in a variety of disciplines is culturally and historically valuable in ways that surpass its traditional role in the history of science (which is substantial but far from exhaustive). In fact, alchemy's explanatory strength lies in its capacity to toggle between the seemingly incongruous realms of practice and metaphor. As we have seen, this is largely due to the worldview that informed alchemical practice and which constitutes an ancient yet nonetheless culturally pervasive, conception of matter. As a result, the original spirit of alchemical thought and practice firmly disallows the separation between material practice and symbolic representation.

There is a vast repertoire of alchemical terms that are used with surprising frequency as metaphors in a variety of contexts. These metaphors convey the act and state of transformation with remarkable precision. The elaborate symbols and terminology used in alchemy did, in fact,

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[270] John. Read, *Through Alchemy to Chemistry: A Procession of Ideas and Personalities* (London: G. Bell and Sons, Ltd., 1957), p. 13.
[271] David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Relgious, and Institutional Context, 600 B.C. To A.D. 1450.* (Chicago: The University of Chicago Press, 1992).
[272] *Ambix* (Cambridge, England: W. Heffer & Sons, Ltd., 1937-2003).

refer to actual procedures at one time, despite the fact that the richly allegorical and mythical nature of this symbolism is regularly plundered for its convenient and compact explication of psychological transformations.[273] Today, psychological meanings are extracted from these terms, thereby divorcing them from their original, alchemical context. An excellent example of the historical permutation of alchemical terms is sublimation. As both a literary movement and a psychological term, sublimation bears in its contemporary usage some of the residue of its original context. Alchemically speaking, to 'sub-lime' a metal is to convert it directly from a material to a gaseous state. Chemically speaking, this is an intense process, since it amounts to a radical conversion of one form into a form that it is the least like, by burning away the body of the substance. In other words, the normal progression from solid, to liquid or stone, and then to gas, is bypassed.

The 'sublime' was, of course, a foundational concept to nineteenth century Romanticism. The 'sublime' for the Romantics represented the simultaneity of the uncanny—its concomitant fascination and horror. To experience the sublime is to be utterly pressed under it, and humbled by a force over which the human creature has no control. Yet there is intense pleasure in this experience as well. Presumably, such an experience was akin to a mystical union with the divine, through which one was suddenly catapulted into an altered state of consciousness. One might even call this a 'transcendent' experience—a momentary abandonment of the body and its limited perceptions.

The alchemists believed that transcendence could be realized through empirical and psychological sublimation. In fact, such a moment of transcendence would take place on both

[273] Jung, *Psychology and Alchemy*. For the most part taking its cue from Jung's well-known application of alchemical themes to the field of psychology, there is an enormous body of contemporary literature on alchemy and healing and/or personal transformation housed with the New Age sections of Barnes & Noble, Amazon, and Borders.

levels at the same time. Alchemy is something of a puzzle to our modern minds because it 'means' the same thing for the mind and for the matter at the same time. The alchemical procedure of separating and elevating the pure part of matter through sublimation, helped to explain the simultaneously embodied and disembodied event of transcendence. A state of transcendence is catalyzed by the mind's co-extensive relationship with the sublime object observed. Thus, the Romantic definition of the sublime retains some of its alchemical flavor.

Today, sublimation is used in the field of psychology to refer to the process of submerging body appetites for the sake of a higher purpose. There is tremendous pressure on the individual to deny the instincts and desires in order to redirect these energies into more socially acceptable paths. This term is used in psychoanalytic parlance as "the refining of instinctual energy."[274] In alchemical practice, as in corporeal and psychological experience, the recalcitrance of matter (the body) serves as an obstacle to transformation. This heavy matter must be burned away, reduced, scourged, punished, purified, and so transformed into a lighter, more manageable substance.

For the purposes of this dissertation, I am particularly interested in the way that alchemical metaphors have likewise found their way into discussions of new media technology. Not surprisingly perhaps, these metaphors function well within a context of metaphysical speculations about embodiment, mortality, and transcendence. But why? To answer this question, we must examine the relationship between figuration and concrete practice as it functioned in alchemy proper, before we can begin to theorize why it is that alchemical metaphors are deployed today with such conceptual efficacy.

[274] *The Oxford English Dictionary*. "to subject (a substance) to the action of heat in a vessel so as to convert it into vapour, which is carried off and on cooling is deposited in a solid form."

The ‘sublime’ experience leaves a permanent mark by ‘tinging’ the bearer of that experience indelibly. Like contemporary scholars and authors, and Romantic poets, Paracelsus used alchemical terms as metaphors. However, there are important differences between how alchemical metaphors are used today and how they were used within their original context. Paracelsus did not separate the realms of metaphor and representation from those of practical application in the laboratory. As elaborated in Chapter 1, metaphorical and material realms of human expression and activity were used interchangeably because they were not really understood as opposing ontological positions within the historical context in which Paracelsus lived and worked. Paracelsus is exemplary of the worldview of his milieu in which physical, chemical, technological practices and representation, do not represent fundamentally opposing ways to organize experience and reality.

Paracelsus shuttled back and forth among four registers in his writings: invective against his perceived enemies; the “sophists” (institutionalized learning and ancient authority); rapturous praise of divinely inspired alchemical procedures; detailed descriptions of recipes for conducting these procedures; and last, as is typical of most alchemical texts, and for the modern reader in particular, obscure symbolism. His compendious and remarkably precise knowledge of metals, minerals, and chemical processes, co-mingled with a more mystical conception of transmutation. There are two reasons for this: 1. The operant theory of matter during Paracelsus’ historical moment was one that did not distinguish between the empirical and metaphorical. 2. Paracelsus tried to protect some of his ‘patented’ procedures from his perceived enemies by deliberately obfuscating certain crucial procedures and referring to these procedures symbolically, abstractly, or in some other vague fashion.

Paracelsus brazenly claims that not one among his forbears has been able to obtain the 'elixir of immortality.' "For this purpose I have been chosen by God to extinguish and blot out all the phantasies [sic] of elaborate and false works, of delusive and presumptuous words, be they the words of Aristotle, Galen, Avicenna, Mesva, or the dogmas of any among their followers."[275] Paracelsus' inflated sense of his own importance is well known. His irascible temperament is alternately celebrated and bemoaned by scholars of Paracelsian texts. Paracelsus despised the 'book learning' of institutionalized education and vehemently placed direct experience and observation above theory. Many scholars view this positively as the first faltering steps toward the scientific method, thereby justifying the otherwise embarrassing theological tone in all of Paracelsian texts. These scholars agree that Paracelsus made important innovations in the realm of medicine and chemistry despite the fact that he believed he practiced alchemy through divine ordinance.[276] Through the secular lens of contemporary scholarship, the pervasive Christian, Gnostic, and Neo-Platonic elements that were a common feature of Renaissance scholarly texts, seems naïve today. It is unfortunate that this important historical strand is downplayed in favor of the secularized features of objective scientific experimentation valued today. I wish to show that this is a distortion of the Paracelsian corpus because it indicts a legitimate cultural moment by judging that worldview by present standards. For the purpose of excavating the fossilized skeletal remains of a bygone species with the assumption that such knowledge is extraordinarily valuable in providing us with insights into our own historical

[275] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, ed. Arthur Edward Waite, 2 vols., vol. I (Edmonds, WA: The Alchemical Press, 1992 (1894)), p. 19-20.
[276] Massimo L. Bianchi, "The Visible and the Invisible. From Alchemy to Paracelsus," in *Alchemy and Chemistry in the 16th and 17th Centuries*, ed. Piyo Rattansi & Antonio Clericuzio, *International Archives of the History of Ideas* (London: Kluwer Academic Publishers, 1994), Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science*, *The Eddington Memorial Lectures, Cambridge University, November 1980.* (Cambridge: Cambridge University Press, 1982), Pagal, Walter, "Paracelsus and the Neplatonic and Gnostic Tradition," *Ambix,* Vol. 8. 1960, pp. 125-166. See also "The Prime Matter of Paracelsus," *Ambix.* Vol. 9. 1962, pp. 1-13.

moment, it is precisely in these moments of unabashed religious enthusiasm welded to 'objective' laboratory procedures that are interesting and puzzling.

One might object to the irony implicit in Paracelsian texts that, for someone who despised 'book learning' he certainly wrote a lot of stuff down! But the language and style of the texts are deliberately alienating to all but the adept. Paracelsus is a poor rhetorician. He assumes a certain level of experience and ingenuity with alchemical experimentation such that, the reader can 'fill in the gaps' on his own. The language is pitched toward the adept and not the novice because it does, in fact, assume and encourage practical, intuitive, and experiential knowledge of substances and procedures. Paracelsus seldom provides exact instructions for alchemical transmutation. He often claims that 'it should be obvious' what the alchemist must do next. Despite the medium of expression to which he is confined, Paracelsus believed that alchemical procedures and symbolism constituted much more than linguistic figuration. Paracelsus urges that "for, above all else, Alchemy is a subject which is not comprised of mere words, but only in elaborate facts; just as is the case with the rest of those arts, familiarity with which is gained rather by putting them into practice than by any mere demonstration."[277] Paracelsus reminds us that alchemy is firmly grounded in concrete practices and not comprised solely of a labyrinth of turgid symbolism that meanders through a desert of obscurity. Yet this is an interesting claim given the fact that Paracelsus does, in fact, exploit alchemy's rich plethora of allegorical terms and symbols. Therefore, some explanation of the role of symbolic representation is warranted.

In Paracelsian alchemy, metaphors and symbols refer to concrete practices, and concrete practices refer to psychological realities. These conceptual registers occur simultaneously, yet neither one is reducible to the other. In other words, the worldview that informs alchemical practice ensures that metaphors cannot be viewed as pure linguistic abstractions nor are concrete

[277] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p.89.

practices reducible to psychological or spiritual states. For instance, terms like "the pelican" (the vessels), "the red lion" (sulpher based catalyst), and "the hermaphrodite" (the culminating unification of sulpher and mercury) are used to name actual practices, procedures, and objects. Conversely, relatively simple terms like gold and silver (Sol and Luna respectively) contained multiple meanings. For instance, gold would have referred to the tincture, the elixir of immortality, the male principle, the ultimate goal of the "Great Work" (alchemical success), a metal, a planet (the sun), and to the unifying world spirit or essence—all simultaneously.

There are several levels of relationships between practices and symbols that are understood simultaneously in the text. Gold is used interchangeably with the elixir of immortality since gold is itself a metaphor for immortality. To complicate things further, both of these terms possess multiple manifestations. Sometimes Paracelsus refers to procedures for making actual gold or using gold as a catalyst in alchemical experiments. Gold and silver can be used as catalyst to make more gold and silver because Paracelsus believed (along with everybody else) that "like produces like."[278] At other times, he is using the term gold to describe the qualities of the elixir of immortality. Like the four elements, many terms and substances in alchemy possess both a physical or material manifestation and, at the same time, a spiritual or 'philosophical' aspect that is nonetheless 'real.' For Paracelsus, gold has three manifestations that shuttle between the empirical, the metaphorical, and the spiritual. Gold is "celestial," "elementary," and "metallic." In other words, gold has a celestial counterpart—the sun (gold was thought to be baked in the earth [womb/oven] by the sun).[279] In addition, gold (symbolized by the sun) and silver are described using gendered metaphors engaging in an act of reproduction or the "conjunction." A third force is required to produce a communication between these two

[278] Ibid., p. 66.
[279] Ibid., p. 11.

forces. The conjunction of the female "seed" and the male sperm is catalyzed by a third, mediating mechanism—mercury. Gendered and planetary metaphors are referring to actual procedures within the laboratory.

> We know that there are only two Stones, the white and the red. There are also two matters of the Stone, Sol and Luna, formed together in a proper marriage, both natural and artificial. Now, as we see that the man or the woman, without the seed of both, cannot generate, in the same way our man, Sol, and his wife, Luna, cannot conceive, or do anything in the way of generation, without the seed and sperm of both. Hence the philosophers gathered that a third thing was necessary, namely, the animated seed of both, the man and the woman, without which they judged that the whole of their work was fruitless and in vain. Such a sperm is Mercury, which by the natural conjunction of both bodies, Sol and Luna, receives their nature into itself in union. Then at length, and not before, the work is fit for congress, ingress, and generation, by the masculine and feminine power and virtue. Hence the philosophers have said that this same Mercury is composed of body, spirit, and soul, and that it has assumed the nature and property of all elements.[280]

This passage shows that the male and female principles are on an equal footing during the process of making life or 'an embryo.' This embryo is nothing less than the philosopher's stone itself, a substance that is capable of catalyzing material changes in other substances. The philosopher's stone is comprised of both Sol and Luna, Gold and Silver.

Finally, gold is, of course, a real metal—a corporeal body. Each is incapable of further purification or reduction since gold the metal and gold as a metaphor for essence, is the common denominator of all matter. Alchemy sought to artificially reproduce the animating spirit which it associated with the philosopher's stone, also known as the elixir of immortality, not because a draught of it would bring eternal life, but because it was a substance capable of creating copies of gold.

[280] Ibid., p. 66.

Gold and the elixir of immortality are used interchangeably in Paracelsus' writing, but they share the quality of being 'golden' in both the metaphorical and empirical meanings of that term. It is important to note that gold is simultaneously, the goal or material outcome of the process and at the same time, the dynamic process through which that goal is obtained. The elixir is described as a golden substance and a golden substance can be both empirically real and spiritually real. On both levels, gold is a substance that is indestructible and because of this, is capable of catalyzing transmutations in other substances. One manifestation of the elixir of immortality differs materially from gold the metal, in that it is a type of medicine or "potable gold." Paracelsus claims that vitriol, known today as sulfuric acid, has medicinal uses. Vitriol is a "golden substance" due to its perceived capacity to heal once it is cleansed of its corrosive aspects.

> Nor let it be regarded absurd that we assign such great virtues to vitriol, for therein resides, secret and hidden, a certain peculiar golden force, not corporeal but spiritual, which excellent and admirable virtue exists in greater potency and certainty therein than it does gold. When this golden spirit of vitriol is volatilized and separated from its impurities, so that the essence alone remains, it is like unto potable gold.[281]

Paracelsus here describes the 'spiritual' force of vitriol. The golden essence of vitriol is a force and not a physical thing. Yet, within the same passage, Paracelsus seems to indicate that the culmination of the process of purifying vitriol, is 'potable gold'—or an actual thing that can be consumed.

The changing status of gold as both material object and a metaphor for spiritual or psychological states raises a central problem in alchemical transmutation. This shift between gold the metaphor, gold the material, and gold the medicine is quite common throughout the Paracelsian corpus. As I have already mentioned, there are two reasons for this—a worldview

[281] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*. p. 62.

that collapses mind and matter, and the desire to instantiate textual obscurity. Aside from his particularly cranky strain of vituperation, Paracelsus' rapid register switching is typical of alchemical writing. What is unique about Paracelsus is that medieval animism and vitalism so completely permeated the work of a self-styled empiricist (one who valued practical application above textual analysis and philosophical speculation). Paracelsus is useful as a transitional figure because his work shows the harmonious commingling of writing styles (the empirical versus the poetic) that we consider today to be stridently opposed to one another.

Alchemists' stylistic strategies of deliberate subterfuge worked so well, that this technique is probably responsible for the misconceptions about alchemy to the present day. Alchemical texts endlessly use symbolic language to allude to concrete procedures that only the initiated could understand. A close investigation of these texts shows that making gold was not the ostensible goal, although it does certainly appear to be the case, since every other word is 'gold' this and 'gold' that. Paracelsus is notoriously difficult to decipher because of these frequent shifts in register. But, as I have already argued, most of these uses of the term are meant metaphorically or symbolically. Hence, gold stood in for something else. This something else could certainly be chemical procedures for producing substances other than gold.

On the surface, the goal of alchemy seems to be to turn base metals into gold and this perception has endured among the uninitiated for centuries. Instead, I posit that considering alchemical metaphors and alchemical practices apart from one another contributes to a fundamental distortion of the original spirit of the alchemical art. Paracelsian slippage between metaphor and practice also served as a rhetorical device. Paracelsus wanted to protect his patented techniques from the greedy and profane grubbing of pseudo-alchemists. Paracelsus feared that these charlatans would use his hard won knowledge of alchemical procedures (which

was nothing short of sacred) for material gain. "It is difficult to reproduce some of the processes that Paracelsus described, partly because he made deliberate omissions in the interest of secrecy." [282] Linguistic barriers in the form of deliberate vagueness, symbolic language, and outright omissions, were built into alchemical texts as a means of protecting successful experiments from the altruistic aspirations of the dreaded 'sophists' or those who would colonize technological innovations for profit rather than for the public good. In addition to monetary greed, the sophists (philosophers) and pseudo-alchemists (craftsmen) can be equated with secular evangelists and gurus that work the 'self-help' circuit in our own era, providing the public with schemes to 'get rich quick' or to magically transform the body and spirit in a compressed or abbreviated span of time; familiar in contemporary terms as, 'Be the person you want to be in 90 days.' 'Lose 20 pounds in one week.' The inherent promise of alchemical transformation is tremendously seductive since on a material level, it claims to artificially accelerate and thus, reduce the human labor required to make money, lose weight, or "win friends and influence people." The promise of instant metamorphosis pervades the material alchemy of yesterday and the spiritual alchemy of today.

Another important reason that Paracelsus used gold interchangeably as the object of material practices and as a metaphor is due to the larger cultural context that he lived and worked in. For hundreds of years prior to the scientific revolution, the theory of a unifying principle bound the universe, the practitioner, and experimental procedures together. Metallic bodies, humans, and things, have outward bodies that change form and an internal soul or essence that does not change. Each of these bodies operates according to the same universal law that governs the relationship between matter and form everywhere in the cosmos. Therefore, for Paracelsus, mind and matter are co-extensive. The process of observation meant that the mind and the object

[282] Gillispie, ed., *Paracelsus*.

being studied were bound together. In a sense, this twofold view of materiality was not completely inaccurate. Modern chemistry acknowledges an indestructible quality to all matter. Unlike alchemy, however, essence is located in energy and not in matter. The first law of thermodynamics describes the natural process of entropy such that, matter and energy can't be destroyed but can be turned into each other. If you lose matter you gain energy, and vice versa. The total amount of energy available remains constant.

For philosophers and historians of science, this textual ambiguity amounts to unfortunate linguistic baggage burdening otherwise remarkable steps toward true scientific practice—the evolution toward objectivity. For the scholar of the cultural history of technology however, this conflation of the material and spiritual realms must be carefully examined rather than dismissed, precisely because it confounds the evolutionary model of the history of science. Alchemy is a fertile ground for a revision of the standard narrative of technological and scientific development because it shows that the transition from a spiritual and animistic worldview occurred very slowly, if it even occurred at all. There is more evidence to support the claim that the standards of modern science, objectivity and empiricism only existed in textual representations of an elite profession that foisted a particular agenda upon posterity.

The symbolic and metaphorical expression of experimentation was important to the alchemists. Likewise, it is this aspect of alchemy that provides a readily accessible testament to its endurance. Although, I will argue that its continuity runs deeper than that. Unfortunately, because of the psychological approach to alchemy which only focuses on its symbols, it reduces hundreds of years of empirical practice to a spiritual metaphor. My goal in focusing on the practical, material, and empirical side to alchemy is not to vindicate it as legitimate science, but rather to link its goals and operative theories of material transformation to contemporary

speculations regarding the manner in which digital media evoke the condition of embodied and material existence by using, practically and theoretically, a representative system that is, as Lunenfeld claims, "etherealized."

One goal of alchemy is to obtain an elixir of immortality. Paracelsus believed that alchemical experimentation could discover a way to artificially prolong human life. He explains this elusive, yet highly, valuable goal:

> Hermes, Plato, Aristotle, and other philosophers, flourishing at different times, who have introduced the Arts, and more especially have explored the secrets of inferior Creation, all these have eagerly sought a means whereby man's body might be preserved from decay and become endowed with immortality. To them, it was answered that there is nothing which might deliver the mortal body from death; but that there is One Thing which may postpone decay, renew youth, and prolong short human life . . . Therefore, the above philosophers, and many others, have sought this One Thing with great labour, and have found that that which preserves the human body from corruption, and prolongs life, conducts itself, with respect to elements, as it were like the Heavens . . . But it is a skilful, perfect equation of all the Elements, a right commingling of natural forces, a most particular union of spiritual virtues, an indissoluable uniting of the body and soul. It is the purest and noblest substance of an indestructible body, which cannot be destroyed nor harmed by the Elements, and is produced by *Art*.[283]

In this passage, Paracelsus claims that natural processes, specifically the 'right commingling of natural forces' can be copied or reproduced by the alchemist. What does Paracelsus mean by Art? It is important to clarify this since, elsewhere in the text, he makes the distinction between Art and artifice or false copies. Paracelsus uses 'Art' to describe the process through which the alchemist attempts to copy natural law, more or less accurately. "Summarily, then, the matter of the Philosopher's Stone is none other than a fiery and perfect Mercury extracted by Nature and Art; that is the artificially prepared and true hermaphrodite Adam, and the microcosm"[284]

[283] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*. p. 23-25 [emphasis mine].
[284] Ibid., p. 66.

Accurate replication of natural and divine realities is possible because of the relationship between the macrocosm and the microcosm. In other words, the earth and all that dwells on it, is a perfect copy of divine operations of the 'heavens' or the stars. If the alchemist wants an authentic replication of these natural laws within the laboratory, he must manifest the appropriate reverence for the 'original' macrocosm and all its operations.

Prior to the scientific revolution, nature, as the perfect copy of a divine plan, was not to be forced to submit to objective scrutiny. Rather, the perception of nature that is conveyed in Paracelsian texts is one of great respect. The artistry of copying nature leads Paracelsus to view transmutation as a craft that required a hands-on approach, despite the trials and tribulations that that approach entailed. Alchemical experimentation is inexact and requires the patience to trust in the skills garnered through experience and intuition. The alchemist must learn to adapt to and work with nature's laws. These laws are active and personified, rather than static, and demystified. Therefore, the alchemist must cooperate with the laws that bind the macrocosm and the microcosm together. In Paracelsian alchemy, nature is not a passive object of scientific scrutiny, but an extremely wise and potentially dangerous agent of transformation. The spirit of nature might support or destroy the alchemist's work. But how, according to Paracelsus, does the alchemist reproduce natural laws in an artificial fashion? The first mechanism of replication is the mediating technology of the catalyst and the second is the proper observation and manipulation of time itself.

It turns out that the catalyst, a substance that like gold has many names (it is also called Lili), is more valuable to Paracelsus than gold itself. Gold the metallic substance is inert, while the philosopher's stone (one name for the catalyst) harnesses the animating or life-giving spirit of nature. It is capable of bestowing life-likeness on metals. However, its significance exceeds its

application in the alchemical laboratory since the philosopher's stone contains the secret of life itself and is therefore, linked to the pervasive alchemical quest for immortality. This precious elixir is produced through a series of refinements and purifications, which ostensibly could be mistaken for attempts to make gold by contemporary historians and the pseudo-alchemists of Paracelsus' day. Recall that references to the philosopher's stone as catalyst could be used interchangeably with the term for gold itself. It would have been easy to misunderstand the 'true' goals of the practicing adept.

The essence of the body, and the essence of gold, can be extracted from a metal through the process of purification. This essence (also known as the soul) can be used as a catalyst to produce transformations in other substances and materials. The catalyst is sometimes referred to as the 'quintessence' or the 'tincture.' As such, it is not gold itself, but a 'golden' substance in the metaphorical sense—or the Platonic quality of "goldness" which can be represented in varying degrees of accuracy. Thus construed, material gold is not really the goal of alchemical practice. The real goal of transmutation is to harness the animating spirit in order to create a mechanism for copying the metamorphoses inherent in nature whereby one thing is transformed into a different thing. The goal of alchemy is to copy process and not product.

If the alchemist wants to copy nature, then he must observe the proper times and seasons for carrying out the 'Great Work.' Alchemy is centrally concerned with the law of entropy and its absolute relationship to time. All things in nature tend to break down and decay, thereby transforming matter into energy. How could the alchemist artificially reproduce these natural conditions of metamorphosis? Paracelsus depicts three different conceptions of time: astrological and seasonal correspondence, deceleration, and acceleration.

Paracelsus urges practitioners to observe the proper times and seasons when conducting the Great Work. Again, this injunction is motivated by the worldview that pervaded his cultural context, allowing him to view the microcosm of the practitioner and the macrocosm of the universe as coextensive. "Whatsoever man does, the planets do also."[285] "These and the like subjects are the bonds wherewith things celestial are bound up with things of the earth, as may sometimes be seen in their operation even with the bodily eyes."[286] The connectedness between the universe and the alchemist's laboratory meant that they had to conduct their work during those times of year that were auspicious for success, "for the invisible celestial influence and the impressions of the stars are in the very first degree necessary for the work."[287] The proper alignment of the stars and the correct observation of the lunar year were required if the work was to be successful. According to Read, "the preparation of the Stone must begin with the Sun in the zodiacal sign of the Archer (Sagitarrius) and with the Moon in that of the Ram (Aries); and it must end under the conjunctive influence of the Sun and Moon in the Lion." [288] In other words, the process should begin in winter (late November, to early December) be carried through the spring and end in early August. The alchemist had to perform transmutation within carefully cordoned off spatial and temporal zones. The creation of a ritualized demarcation of the sacred was necessary, primarily, because the alchemists wished to curry favor with God. He had to humble himself in this way because he was about to commit a profane act—the violation of natural law through the artificial acceleration and deceleration of time itself.

The relativity of time is accentuated in alchemical practice. In one sense, alchemical transmutation is a very slow process, involving an endless routine of procedures:

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[285] Ibid., p. 42.
[286] Ibid., p. 51.
[287] Ibid., p. 68.
[288] Read, *Through Alchemy to Chemistry: A Procession of Ideas and Personalities* p. 38, [Parentheses mine]

> This tingeing spirit, separated from the other two as above, you must join to the spirit of Luna, and digest them together for the space of thirty-two days, or until they have assumed a new body. After it has, on the fortieth natural day, been kindled into flame by the heat of the sun, the spirit appears in a bright whiteness, and is endued with a perfect tingeing Arcanum[289]

There is one quality that all practitioners of transmutation would have to possess—patience! Transmutation was highly repetitive process of refinement, either by burning or boiling away the dross or dregs of a base metal like lead, to produce a residue ripe for even further purification. "Let them [the dregs] be placed in the fire six hours to liquefy: then renew and liquefy for another six hours. Do the same a third time for twelve hours; a fourth time for twenty four hours." [290] Procedures for the further refinement of the residue might be repeated not just over a period of hours, but also over a period of days and months. One experiment could last several "philosophical months" (40 days).

In another, important sense, the alchemist is also artificially accelerating natural law. In terms of geological time, the alchemist's attempt to make gold is obviously much quicker than the accretion of gold within the earth's core or 'womb.' Since metals evolve slowly over time within the 'womb' of the earth, then the question remained of how to speed this process up within the laboratory. "So it is that in the mineral burrows and caves of the earth, vegetables are found which, in the long succession of time, and by the continuous heat of sulphur, put off the vegetable nature and assume that of the mineral. From this mineral state, too, sometimes a perfect metallic essence arises, and this happens by the progress of one degree into another."[291] A composite of mercury and sulphur flow through the inner recesses of the earth "so that

[289] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great* p. 60.
[290] Ibid., p. 46.
[291] Ibid., p. 64.

scarcely in a hundred years is it transformed into a metal."[292] Paracelsus describes a natural process occurring over many hundreds of years, and argues that the alchemists can produce these same results artificially. The alchemist uses art to produce artificially what nature produces over a long period of time. In this case, Paracelsus is referring to the catalyst mercury that produces a perfect union of opposing forces and as such condenses the essence of the universe at large within its own nature.

What seems like time-consuming, painstaking labor actually amounts to the speeding up of natural rhythms. Alchemical transmutation was a means through which a mediating technology (catalyst) might be used to cheat time and to artificially turn the clock forward. Sometimes, if the experiment is blessed, transmutation will occur very suddenly. "This work, the Tincture of the Alchemists, need not be one of nine months; but quickly, and without delay, you may go on by the Spaygric Art of the Alchemists, and, in the space of forty days, you can fix this alchemical substance, exalt it, putrefy it, ferment it, and coagulate it into stone, and produce the Alchemical Phoenix."[293] The artificial acceleration of natural rhythms places alchemy, along with all technologies that artificially augment the human body, on the border between sacred and profane practices. Like many early (and contemporary) flounderings toward an empirical understanding of the universe, alchemy mucked about on God's sacred turf. "The resuscitation and reduction of natural things is not the least important in the nature of things, but a profound and great secret, rather divine and angelic than human and natural."[294] Obviously, the attempt to achieve immortality through artificial means is to hubristically bend the rules of the universe by cheating Father Time. In an important sense that links alchemical practice to contemporary

[292] Ibid., p. 65.
[293] Ibid., p. 40.
[294] Ibid., p. 143.

digital technology, alchemy sought the catalyst that would fight entropy by extracting the indestructible elements from materials (including the human body).

In addition to the artificial tweaking of time and space, Paracelsus was interested in artificially copying natural law. This theoretical and practical concern serves as the underlying stratum that makes alchemy relevant over and above its ostensible scientific (chemistry) and spiritual (mystical) concerns. The nature of artificiality strikes to the very heart of cultural concerns over technology as alternately celebrated and demonized. To make the artificial—one must copy the processes not the product of natural laws. But in creating an artificial copy of nature, we humans cannot be sure the status of the copy. In other words, is it 'accurate' or 'fallen'? The problem of artificiality will inform subsequent sections of this chapter that deal with the mechanics of alchemical transformation, and the main theoretical and practical problem that Paracelsian alchemy raises—the residue. The status of the real versus the fake was a central preoccupation in alchemical practice and, its failure to resolve this issue in an empirically satisfactory way paved the way for its subsequent denigration as pseudo-science. But as I have already argued, this evaluation is somewhat misplaced since it fails to take into account the cultural motivations behind artificial transformation.

Within the context of Paracelsian alchemy, representation is fluid and dynamic and not static. Three is the number of transformation and two is the number for stasis. As described earlier in this chapter, a third, mediating entity is needed to complete the process of transmutation. This third entity is the catalyst or philosopher's stone that mediates between the dualism perceived by the alchemist in gendered terms. This third item, not surprisingly, has many names. In addition to catalyst, gold, philosopher's stone, Lili, tincture, and the pearl of great price, it is Hermes, Mercury, and hermaphrodite. The alchemist needed this third active,

volatile mediating device to communicate between active spirit and passive ground. The philosopher's stone is what makes it possible to copy nature's processes artificially.

However, in the Platonic sense of the fallen copy, Paracelsus indicates that there is such a thing as a good and bad copy. Color and durability were important characteristics that Paracelsus used to test the authenticity of 'artificial' silver and gold. The central issue is that alchemical practice seeks authenticity, not in making gold, but in copying nature's processes. In terms of the final product, however, the line between authentic versus fake gold would have been blurred in Paracelsus' day since the very nature of a 'successful' transmutation could not be evaluated on an atomic level. In other words, anything more than visible and therefore, superficial proof was often lacking—at least at first. One true test of authenticity is the test of time. Fake gold, or gold-plated materials, lacked endurance and were subject to decay and 'wearing off.' Therefore, despite his belief that alchemy could more or less accurately copy nature, Paracelsus was well aware that there was such a thing as the counterfeit. Not all alchemists wanted to copy processes. Some of them were certainly in the business for financial gain. In fact, Paracelsus warns the true adept to be careful not to divulge precious information (garnered from direct experience) to these self-serving alchemists and their patrons. It is not an exaggeration to say that Paracelsus actually despised these folks almost as much as he despised his learned brethren. However, the distinction between real and fake copies is an especially pressing issue for alchemists whose goal was in fact, to make gold. Their reputation rested upon the successful material manipulation of metals and mineral and what certainly amounted to counterfeiting. Certainly, within its heyday, wealthy patrons employed alchemists for the express purpose of increasing their wealth. This is true of both Arabic and Western alchemy.[295]

[295] Read, *Through Alchemy to Chemistry: A Procession of Ideas and Personalities*.

Paracelsus denigrates these individuals or 'pseudo-alchemists' since he believed that the 'art' of transmutation was more than a matter of merely altering the color or appearance of one metal. The change wrought on the object being catalyzed had to be substantive. "It is true I have seen Mercury by this Art, and by such fixations, brought into a metallic body resembling and counterfeiting good silver in all respects; but when brought to the test it has shewn [sic] itself to be false."[296] Despite the admission that a thing can look 'real' but actually be false, he seems to contradict himself later when he maintains that color, is itself the essence (indestructible part) of a metal. "I call the tincture of gold the colour of the body itself, which, if separated from the body so that a white body remains, will be a perfect work. For colour and body are two different things, and for this reason admit of separation, this is to say, the pure (the colour) is separated from the impure (the body)."[297] Here Paracelsus seems to reverse the standard surface/depth distinction by asserting that the surface is the essence and the depth is the 'dross.' In other words, the surface characteristics are the valuable part of the metal. Interestingly then, essence is easily 'read' on the surface of the thing, it is absolutely clear and visible and not, buried in the core of the material. Further, Paracelsus maintains that even nature cannot produce perfect copies because, in their natural state, no two metals are identical. In fact, no two organisms are identical. According to Paracelsus, differences in temperature produce fine gradations between metals that are ostensibly alike. If nature cannot accurately copy itself, then neither can the alchemist.

> Nevertheless, the final outcome matters less than the process through which changes in metal are catalyzed. Whoever, therefore, is ignorant as to this spirit [the tingeing spirit] cannot have any hopes of fixing it, or of giving it that power which would make it capable of the virtue of transmutation. So, then, I give notice to all that whitening of which I have just now spoken is grounded on a

[296] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 57.
[297] Ibid., p. 156.

> false basis, and that by it the copper is deceitfully whitened, but not changed.[298]

Color alteration enjoys a somewhat ambiguous status in Paracelsian alchemical theory. In one sense, it is a signifier of falsity and in another sense, color is the true essence. This ambiguity is attributable to the status of sense experience in scientific experimentation during this time period. The alchemist had to rely on sense experience as the final test of authenticity, but the human senses could also deceive, and certainly dishonest men could use deception to take advantage of this vulnerability in sense perception. This is a long-term ontological and metaphysical problem that has been treated by philosophers throughout the ages and was not unique to alchemists. However, the alchemist is poised between speculative philosophy and empirical experimentation. As such he occupies a unique position in the history of the relationship between human sense perception and reality, because he is not merely theorizing the nature of reality, but is wholly occupied with the manipulation of real things.

The problem is that, thanks to Aristotle, things are not just detached lumps of clay, they possess an animating spirit as well as a material nature and this animating spirit is absolutely present although it cannot be observed by human sense perception. Obviously, the distinction between surface and depth continues to haunt us today. Walter Benjamin provides a very well-developed theory of the material artifact's relationship to the *spiritus mundi.* Like Aristotle, Benjamin argues in the *Arcades Project* that cultural artifacts contain, in a metaphysical sense, the essence of the historical drift of modernity. I emphasize the metaphysical component because it is important to note that the manner in which historical currents enter into an object is not just theoretical for Benjamin—but really instantiated in the materiality of the thing. This is a quite extraordinary anti-empirical attitude. The idea of the authentic versus the fake copy pivots

[298] Ibid., p. 58, [brackets mine].

around the surface/depth dialectic. In alchemical terms, these two dimensions of a thing are connected by a mediating force that weds them into a unity. The theoretical problem is not the Cartesian problem of object/subject separation, but of understanding the nature of the animating force behind the unity of matter. Similar to the rhetorical arts, an adept alchemist could use his skills for good or for ill. He could do a really good job of counterfeiting gold by providing a plausible illusion (color) of authenticity. Alchemists and their audiences were somewhat vulnerable to these deceptions because of their underlying faith in a relationship between essence and surface. For Paracelsus, the distinction between art and artifice is the deciding factor. The practitioner of the art of alchemy is motivated to render artificially an indestructible substance or to 'fix' or stabilize volatile substances through the seven procedures of transmutation that Paracelsus outlines. In short, the true practitioner is concerned with an accurate copy of the process and not an accurate copy of the product.

The goal of alchemical rendering, according to Paracelsus, is transmutation. A golden substance is, therefore, any substance capable of transmuting one thing or state into another thing or state; such as an old body into a young body, or a material substance into a spiritual substance. The seven steps of transmutation appear in many places throughout his alchemical corpus and were viewed as essential to the mastery of alchemical processing. Paracelsus defines transformation as the process through which "an object loses its own form, and is so changed that it bears no resemblance to its anterior shape, but assumes another guise, another essence, another colour, another virtue, another nature or set of properties."[299] This definition plays upon the reversal of surface and substance elaborated in a prior section of this chapter. Paracelsus lumps essence and color together, as the qualities that might be altered through transformation.

[299] Ibid., p. 151.

Paracelsus' definition of transformation usefully sets into relief the ambiguous relationship between the authentic original and the fake copy. The lack of distinction between depth and surface in this definition might seem strange to us. But Paracelsus was working with a different theory of matter that enabled such ambiguity. A belief in the primary unity of all matter meant that the surface of a substance was indissolubly linked with its essence. Due to Aristotelian metaphysics, as explained in the Introduction to this dissertation, it is possible for one substance to change into another substance because of the presence of a primary substance that is itself unalterable. For example, Paracelsus claims that:

> In a word, whatever is to pass into its ultimate matter must become something different from what its origin was—varied and diverse, though from one mother. Thus God willed to be One in all, that is, to be the one primal and ultimate matter of all things. He is such, and so wonderful, an original artificer of all things as never has existed, nor will another ever exist.[300]

All change flows from one source. Yet this one source expresses itself in a myriad of diverse forms. The philosophical paradox pondered and elaborately theorized by the ancients is that, within the midst of difference and change, there is unity—some 'thing' that is unchanging. Therefore, the relationship between transformation and stasis is symbiotic.

These two processes cannot really be understood apart from one another since the existence of each implies the existence of the other. The mantra for alchemical transmutation (borrowed wholesale from Aristotle) is that things are capable of transmutation because they possess an underlying similarity, which Paracelsus deems to be God, the "original artificer," working with the "ultimate matter." Turning base metals into gold and producing an elixir of immortality was, therefore, nothing short of harnessing this underlying and universal essence common to all matter. This ultimate matter, or primary substance, is very powerful and

[300] Ibid., p. 91.

potentially dangerous stuff. The alchemist was harnessing nothing short of the principle that moved the earth and heavens alike, the supra-divine clay out which all things are not only made—but are animated. Therefore, as seen in the prior section of this chapter, Paracelsus urges his readers not to disseminate alchemical knowledge carelessly to the foolish mountebanks, charlatans, and quacks. "Here you have the Art altogether, clear and entire. If you do not yet understand it, or are not practiced therein, it is well. It is better that it should be kept concealed, and not be made public."[301] Likewise, the sacred secrets of alchemy are protected through an elaborate symbolic system that only those who have been properly initiated can 'read.'

The ultimate matter, also referred to by Paracelsus as the "quintessence" is sought through a repetitive process of separating the soul from the body, or the essence from matter. "Whatsoever pertains to separation belongs to the science of Alchemy. It teaches how to extract, coagulate, and separate every substance in its peculiar vessel."[302] The process of repeated purification is followed by coagulation. Not surprisingly, the goal is to rejoin the body and soul through coagulation, also referred to the 'alchemical wedding.' "The body will receive and embrace the soul; since the body is affected with extreme desire for the soul, and the soul is most perfectly delighted with the embrace of the body." [303] Expressed allegorically (and politely), the union of body and soul is equated with sexual intercourse.

Technological (artificial) augmentation tries to copy biological transformation. This was what Paracelsus was after and it continues to be a goal of technological innovation. The biological metaphor is both an allegorical means of expression at the same time it signals the material instantiation of a process of replication. The ostensible goal of alchemical transmutation is the purification of gross matter. In other words, alchemy teaches that transformation is always

[301] Ibid., p. 14.
[302] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 42.
[303] Ibid., p. 62.

an embodied event. It is never purely transcendent, i.e., the spirit never leaves the body because the essence must always find expression in material form. More inadvertently, however, (and this will be discussed in greater detail in the next section) the embodied nature of alchemical transmutation is illuminated through the magical appearing and disappearing acts that substances engage in during the process of transmutation. The shape-shifting quality of matter emerges from the explication of seven steps. Substances are combined, separated, and then recombined and separated yet again. They are transformed into ashes, liquids, stones, and oils. The greatest strength of alchemical transmutation, its purification of the soul/body relationship here on earth, turns out to be the source of an empirical problem: transformation generates waste. The various metals never disappear completely and this stubborn persistence of matter results in the problem of what to do with the 'dross' or leftovers.

Paracelsus identifies seven stages of transmutation: calcination, sublimation, solution, putrefaction, distillation, coagulation, and the production of a tincture. He explains that each of these seven steps should follow one another in succession as "rungs of a ladder." The metaphor for climbing to ever greater heights is intentional, since the process culminates in the tincture or philosopher's stone—a substance that can create golden objects as well as golden and hence, immortal soul. Each of these stages results in more procedures, rather than an end product. In short, a type of interface tool emerges; or a tool designed to enable more transformations. The process of artificial transformation through the seven steps of transmutation shows that it is, essentially, a process of continual separation and conjunction. Paracelsus coined his own phrase to describe this process—spagyric, which means to dissolve and bind.[304] Over and over again, one body or metal is, through burning, boiling, and vaporizing, divided into two bodies.

[304] D. Fernando, *Alchemy: An Illustrated a to Z* (New York: Sterling Publishinig Co., 1998).

It bears repeating that Paracelsus was more interested in the process of catalyzing transformation than in the end product of transformation itself. At the very least, he waxes ambiguous (for reasons explained in the prior section) about the outcome of these procedures. In other words, whether or not the seven steps actually produce gold, or the much beloved elixir of immortality, remains shrouded in misty obscurity. The real focus, for Paracelsus is the creation of a mediating tool or catalyst that will effect transformations on other substances. The final stage of transmutation results in a tincture, which is a highly concentrated substance that can 'tinge' or alter the quality of other substances.

In what follows I will describe each of the seven stages in Paracelsian alchemical transmutation in order to demonstrate that these procedures do not culminate in a final product but result in more processes and, curiously, generate more and more matter rather than less. The promise of purification is frustrated by the fact that, at the end of a given procedure the alchemist has to figure out what to do with the leftovers—the stuff that collects at the bottom of the retort after burning or boiling. Should he throw it away? Or, should he submit it to further refinements?

The first step in alchemical transmutation is calcination. Calcination reduces a metal to ash and carbon through an exceedingly hot flame. "By Calcination all metals, minerals, stones, glasses, and all corporeal objects, become carbon and ashes; and this is done in a naked fire, strong and exposed to the air. By means of this all tenacious, soft, and fat earth is hardened into stone; but all stones are reduced to lime."[305] Paracelsus does not spend a lot of time on the process of calcination. Calcination produces the first, radical act of combustion that is followed by slower, more temperate processes. Paracelsus compares these artificial alchemical procedures to authentic natural operations. The alchemist's job is to, more or less, accurately mimic the operations of a fully anthropomorphized 'nature.' The process of calcination occurs more slowly

[305] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 151-152.

in nature, however, during the process of fossilization whereby the "fat earth" of a body is transformed into stone. Fossilization, amounts to the substitution of a hard skeletal substance for the soft fleshy one through a concretion of lime. The original structural features of the organism remain intact as a visible remnant of the former creature. Calcination is the first step in the process of separating the pure material from the impure material by removing the heavy dross. It is akin to an artist's broad swaths of color across a canvas before she proceeds with the finer detail, or a rough draft to be followed by editorial refinement.

The residue that is left over after calcination, becomes the object for sublimation. This procedure refers to the process of separating heavy material from light material in yet another variation on the theme of separating pure from impure substances. Chemically, sublimation refers to the conversion of a solid form into a vaporous form and then, back to a solid form again. Sublimation is similar to distillation, except that distillation involves liquids while sublimation is a 'dry' process. In alchemical terms it is a process of purification whereby, "the spiritual is raised from the corporeal, subtilised [sic], and the pure separated from the impure."[306] The vapors produced through sublimation are later cooled and returned to a solid form, showing that the ultimate goal of sublimation is to convert an elevated or gaseous state back to an earthly or material state.

> One takes for granted that, although Paracelsus' description of sublimation is characteristically vague, he is talking about actual chemical procedures. Many excellent virtues and wonderful qualities are found in minerals, and many things are fixed and become permanent, so that they remain in the fire in the following way: Let the body which is sublimated be ground again and mixed with its own dregs. Let it again be sublimated as before, and let this be repeated until the sublimates no longer, but all remains in the bottom and fixed.[307]

[306] Ibid., p. 152.
[307] Ibid., p. 152.

Clearly, sublimation involves a good deal of patient working and reworking of materials. Also, Paracelsus does not tell us what the 'excellent virtues' produced through sublimation are. Sublimation is a gentle and persistent process and not, the violent scourging through flame produced through calcination. It involves a repetitive process of taking the residue and subduing, processing, and purifying it over and over again, for the purpose of creating a lighter, more buoyant and malleable substance. This process, as with each of the seven stages, possesses a spiritual counterpart that Paracelsus describes as "exaltation, conjunction, opposition and kindred processes are not materially performed, but after a mode which is altogether spiritual."[308]

Interestingly, Paracelsus describes the process of recombining the purified substance with its own residue or 'dregs' that are left behind in the process of creating that purified substance. The leftovers play an important role in subsequent refinements. Sublimation seeks to recycle the residue, the remainder, the excess, or the trash, thus indicating that the goal of alchemical transmutation is the transformation of matter—not its transcendence. Nothing is left behind, nothing is thrown away.

The next step, solution, is the process through which the residue from the former procedures is transformed into a liquid state with the intent of ridding the material of its corrosive substances. In other words, solution is an attempt to get rid of the stuff that is left over from sublimation by dissolving it. Up to this point, each phase of transmutation follows a pattern of converting, through fire, matter to more matter, then matter to gas and then, back to matter again. In the process of solution, the alchemists convert matter to liquid. "This step frequently follows after Sublimation and Distillation, as, for instance, when you dissolve the matter which remains at the bottom."[309] There are two steps in the process of solution: one by heat and the

[308] Ibid., p. 152.
[309] Ibid., p. 152.

other by cold. Heat obviously refers to cooking a substance through the application of fire, while cold refers to the process of drying or dissolving material through the application of liquid or air. "But the Solution of heat dissolves all fat and sulphurous bodies; and whatever the heat of fire dissolves this the cold coagulates into a mass, and whatever the heat coagulates, this the air and cold again dissolve."[310] Paracelsus describes that there are two mutually exclusive ways of processing residue through solution. Heat dissolves the material created through cold solution, while cold dissolves the material created through hot solution. Various meanings for the term solution include, an answer, a decision, a setting free, release, deliverance, the act of breaking up or separating, dissolution, and bringing to an end. According to the *Oxford English Dictionary*, dissolution is "the separation from each other of normally continuous parts of the body by external or internal causes."[311] There is more evidence of the shape-shifting qualities of matter in solution. Again, it is clear that through alchemical transmutation, substances change color, shape, and consistency. However, these substances never seem to turn into a thing that is essentially different from what it originally was.

Putrefaction is an alchemical procedure that refers to the decay or dissolution of natural, mineral, or metallic substances. It is a 'gross' process, both in the traditional and pejorative sense of the term, since it refers to the process of decomposition. "Putrefaction is of so great efficacy that it blots out the old nature and transmutes everything into another new nature, and bears another new fruit. All living things die in it, all dead things decay, and then all these dead things regain life."[312] No body or substance dies completely in alchemy. All bodies are converted into something else, and ideally, something better. Dissolution, decay, and regeneration are pivotal concepts to both alchemical and digital transmutation because both represent the longing to

[310] Ibid., p. 153.
[311] *The Oxford English Dictionary*
[312] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 153.

transcend the corporeal framework by rendering it immortal. Putrefaction magically resurrects dead and inert substances and tissues. Paracelsus considered this an extremely important stage in transmutation, stating that it might come first if that were not "contrary to the just order." Putrefaction is of singular importance because it is the process through which seemingly inert or dead materials regain life. Alchemical mechanisms animate bodies by ridding them of their clunky dead weight, thus rendering them more malleable. This amounts to, as each of the stages described above do as well, ridding heavy matter of its dross in order to produce a lighter, and more manipulable substance.

Putrefaction shares a counterpart with human bodily process in that Paracelsus also compares it to digestion. The process of decay and digestion are natural processes that take time and energy. In both cases, matter is converted into energy—likewise in alchemy, putrefaction involves the extraction of the valuable essence of a substance from the useless dross that congeals around it. Part of the material 'dies' so that its 'soul' might regain new life. Paracelsus explains alchemical digestion as the process through which

> what is bad and unprofitable in a substance is separated so that the substance remains in its essence, as it was created. Between digestion performed in the earth and the digestion that takes place in the body of man, there is this difference, that the earth separates nothing, in the sense that it does not cast out anything excrementitiously; it digests, putrefies, generates and augments by the power and ministry of the stars.[313]

Here, as in numerous other places throughout his texts, Paracelsus insists upon the importance of keeping and recombining the residue of the alchemical procedures because nature does not produce waste. "Nature, indeed, herself does not bring forth anything into the light which is not

[313] Ibid., p. 153.

advanced to its highest perfection."[314] Paracelsus urges the practitioner to mimic, as closely as possible, natural procedures since these are superior to artificial ones.

The next step, distillation, involves the extraction, in liquid form, of the essence of a substance. By essence, Paracelsus meant the valuable part of a metal or substance. Each of the procedures of transmutation are, in slightly different ways, procedures for separating out the essence. However, Paracelsus was, of course, interested in the quintessence since one could not produce a philosopher's stone without it. The quintessence is an Aristotelian concept meant to account for the existence of a fifth element. "Hovering behind these four elements was a shadowy and ill-defined fifth. Aristotle called it ether, the element of the stars; the neo-Platonists called it Logos, otherwise known as the *quinta essencia,* the fifth being, or quintessence, sometimes confused in alchemy with the Philosopher's Stone."[315] Paracelsus was also interested in the essence of metals since these constituted important ingredients for curative medicines. It is this belief in quintessence that lead Paracelsus to conclude that alchemical transmutation is, fundamentally, a process of separation and extraction. Paracelsus, the physician, was interested in the medicinal value of the various metals. In several places in his texts, he discusses procedures for extracting oils and for the further refinement of these oils. "By Distillation all waters, liquids, and oils are subtilised, [sic] the oil is extracted from all fat substances, the water from all liquids, and in all phlegmatic substances the oil and the water are separated."[316] Distillation has lead to the expression of "boiling something" down to its main constituents since it refers to extracting the essence of a substance from the superfluities that clutter around it. This extracted essence is more potent (the distillation of alcohol and perfumes are good examples of this) than it was in its original form.

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[314] Ibid., p. 28.
[315] Read, *Through Alchemy to Chemistry: A Procession of Ideas and Personalities*, p. 3.
[316] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 153.

Each of the steps described thus far refer to a loss of material or the peeling away of superfluities, either through absorption, separation, or burning. The goal has been to remove the unwanted excess and subsequently, the problem results as to what to do with that excess once it has been removed. Which is the most valuable, the stuff that is removed or the thing that is left behind after stuff is removed? One possible solution to this problem lies in the process of coagulation. In coagulation, the goal is to recombine things rather than to take them apart. Coagulation is "the act or process of forming or uniting into a mass; concretion, cohesion."[317] This step is associated with conjunction, also known as the alchemical wedding. Conjunction through coagulation refers to the reunion of body and soul as represented in the union of male and female in the figure of the hermaphrodite. This is a very important step that is much celebrated in the alchemical literature. The body and soul are rejoined, thereby showing that alchemical transmutation offers a theory of material transformation in which elements are pulled apart, purified, and put back together again. The result of alchemical procedures is the conjunction, also known as the alchemical wedding whereby the body and soul "embrace" one another. Materially, this metaphorical expression refers to the interaction between mercury and sulphur within the alchemical retort (oven and vessels).

Alchemical transmutation suggests that the relationship between the body and soul is that immortality might be achieved through an earthly existence. Therefore, residue and essence are rejoined rather than thrown away. Transcendence or resurrection is not what Paracelsus sought. Even though alchemical practice joined spiritual and material realms, this does not mean that the goals were not practical. Alchemists sought to harness the quintessence in order to be able to manipulate the materials at hand. The problem is that, in the process of copying nature, waste is

[317] *The Oxford English Dictionary*

generated. Artificial transformation is somehow incomplete. The copy of nature leaves an annoying remainder, a material reminder of human imperfection.

The final and most important step for Paracelsus is the procedure for obtaining the tincture, "which concludes the work of our mystery" and,

> Makes all imperfect things perfect, transmutes them into their noblest essence and highest state of health, and changes them to another colour. *Tincture, therefore, is the noblest matter with which bodies, metallic and human, are tinged, translated into a better and far more noble essence, and into their supreme health and purity* . . . But there are many and various Tinctures, and not only for metallic and human bodies, since everything which penetrates another matter, or tinges it with another colour or essence, so that it is no longer like what it was before, may be called a Tincture . . . For if the tincture is to tinge, it is necessary that the body of the material which is to be tinged should be open, and in a state of flux; for unless this were so, the tincture could not operate.[318]

The tincture is the pure essence of a metal and it is the "noblest matter" due to its power to transform other substances. The tincture is Paracelsus' version of the philosopher's stone. The philosopher's stone is as pervasive a metaphor as alchemical gold. But it should be noted that these are two different things. The philosopher's stone is a catalyst or tool that can be used to transform base metals into gold or into the elixir of immortality. As such, it is both an end in and of itself. In some sense, the philosopher's stone is both a culmination and a dynamic process. The idea that alchemical rendering involves the recombination of the essence with its dregs is linked to the idea of the tincture as catalyst. Apparently, in addition to being themselves the products of transformation, the leftovers can likewise be used to catalyze subsequent transformations. Therefore, the goal of these seven steps is to produce, not a static substance (gold) but rather, a tool for producing transmutations in other bodies. Curiously, at the end of his

[318] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 155 [emphasis Paracelsus'].

journey, the alchemist finds that he has reached the threshold of yet another journey. An artificial thing used to create more artificial things.

The tincture also explains the importance of the elixir of immortality in Paracelsian alchemy. As a process, the tincture is a catalyst for transformation. More specifically, its purpose as an elixir is to bring dead flesh back to life or to convert diseased bodies into healthy bodies. At the culmination of the seven stages of transmutation, Paracelsus claims that

> There is nothing at this stage which need delay the operator; only let him put before himself a fact which has been passed over by the philosophers, and by some studiously veiled, namely, that in projections there must be a revivification, that is to say, and *animation* imperfect bodies—nay, so to speak, a spiritualization; concerning which some have said that their metals are no common ones, since they live and have a soul.[319]

The tincture or elixir was valuable to Paracelsus for its healing properties and for the transformations it could produce in human bodies. In the simplest sense, the elixir of immortality as a medicine might turn back the clock, transforming the old into the young. Therefore, the goal of alchemy is to "laud process over goal."[320] The tincture serves as a mediating technology that unifies the human body and metallic bodies since both are subject to the laws that govern the dynamic relationship between matter and form. These same laws are what make it possible for Paracelsus to say that metals "live and have a soul," in the passage quoted above.

Paracelsus here describes the final stage in transmutation—projection. Projection occurs by using a small amount of the tincture or quintessence to transmute a large piece of molten metal into silver or gold. But precisely what remains to be done empirically at this final, and crucial step, remains unclear since Paracelsus switches to an occult or esoteric register of explanation. The operator, therefore, only needs to figure out how to reanimate dead substance to

[319] Ibid., p. 64.
[320] Peter Lunenfeld, "Unfinished Business," in *The Digital Dialectic: New Essays on New Media*, ed. Peter Lunenfeld (Cambridge: The MIT Press, 1999), p. 8.

achieve this 'spiritualization' of the metal. Another way of sidestepping the problem of the final transmutation of a metal into the philosopher's stone is to indicate that these procedures and significantly, the one's that befuddled the philosophers or 'book learned' men, are already well known in a practical sense by true craftsmen. "But concerning the Tinctures nothing more need be written, seeing that every extracted colour may be called a Tincture, which, indeed, tinges with a permanent colour things which do not enter the fire, or keep their colours fixed in the fire. All these things are in the hand and power of the dyer or the painter, who prepares them according to his own pleasure."[321] This reference to the common laborer as a true alchemist is typical for Paracelsus since he despised institutionalized learning of the elites, hence his constant vituperating at the expense of the 'philosophers' or 'sophists.' "In the mountain commonly called Kuttenberg they obtain a lixivium out of marcasite, in which iron is forthwith turned into Venus of a high grade, and more malleable than the other produced by Nature. These things, and more like them, are known to simple men rather than to sophists, namely, those which turn one appearance of a metal into another."[322] Paracelsus spent a lot of time hanging out and drinking at the local dive bars where he rubbed shoulders with all manner of so-called common folk—laborers and artisans.[323]

Deliberate omissions and obscurity notwithstanding, Paracelsus provides some concrete procedures for the burning (the most important process in alchemical experimentation), dissolving, recombining, and processing of chemicals and metals. Yet he is much clearer about procedures to accomplish results other than a golden substance. In the explication of the seven stages, just when he should be getting more specific about what to do, he either becomes vague

[321] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 156.
[322] Ibid., pp. 28-29.
[323] E. D. Waite, *The Secret Tradition in Alchemy: Its Development and Records* (New York: Alfred A. Knopf, 1926).

or shifts to an symbolic register. For instance, Paracelsus frequently claims that if such and such a procedure is accomplished, then "many great and wonderful Things will arise from it." But he is silent about what these great things are. In addition, Paracelsus speaks on two registers as he describes what seems to be on the surface, a purely objective operation, turns out to be in the footnote, taking place on a rather different plane of experience. Paracelsus, in characteristic crankiness, rewards true scholars who care enough to read the small print. Some of his more provocative claims are conveyed in footnotes.

The seven stages of transmutation allow us to deduce that alchemical procedures result, despite its goals of further and further refinement, in a residual material. Therefore, alchemical transmutation purposefully and inadvertently seeks artificial transformation of the body, and not its utter transcendence. Artificiality generates waste. In the following section I will discuss the dilemma of the residue for the alchemists and what this problem tells us about alchemy as a technology for the artificial extension of human life.

The alchemical remainder is pivotal to ruminations about the status of artificial copies of nature, since, presumably humans produce waste and nature does not. In other words, all dead tissue is recycled by being transmuted or converted into energy that in turn sustains other life forms. As noted in the culmination of the seven stages of transmutation, Paracelsus treats the outcome of alchemical procedures ambiguously. The arrival at the final destination, making gold, a tincture or an elixir, seems always just on the horizon, as complex procedures generate more rather than less, matter. The object of purification is to burn off the excess, 'dross,' or impurities that congeal around base matter. But curiously, the excess never really goes away. Rather, the reprocessing of the leftovers or "dregs" becomes an important part of the procedure.

Metals and substances are mercurial shape-shifters, endlessly changing from solid to gas to liquid and back to solid again.

Paracelsian alchemy addresses at least two significant issues that merit closer attention. The first is the problem of the remainder that is left behind in the process of trying to mimic nature's efficient recycling program. Presumably, you cannot endlessly copy a thing or a procedure without generating waste. The alchemist was supposed to end up with a thing (gold) and instead, ends up with more and more procedures for the refinement of the material that is left behind since the leftovers are crucial to catalyzing further transmutations. This presents something of a dilemma for Paracelsus. According to Paracelsus, nature accomplishes the most perfect transmutations since nature does not leave a residue. Even dead material is converted to energy. Presumably, to change one thing into another thing through transmutation means converting, on a substantive level, the material composition into something different. Such a process should not result in a residue.

The residue is a uniquely human quality and a clear sign the alchemist is not, in fact, accurately mimicking natural processes. Paracelsus suspected that the process of burning was not always catalyzing a chemical change, but merely altering the form of the substance. A chemical change would be irreversible. Things that are destroyed through fire cannot (the fleshy part) be recovered. Artificiality pays for the profanity of trying to mimic natural law in mountains of waste. The question of whether this material is the valuable essence extracted from the original substance or whether this material is useless waste, remains ambiguous in the literature. Everything ought to be susceptible to further refinement.

Throughout each of these steps, it is clear that the alchemist did not seek a complete denial of bodily existence. Rather he sought to subject the substance, body, or metal to a seemingly infinite number of purifications in an attempt to *transform* the body, not *transcend* it.

> But concerning spiritual mixture and communion of metals, it should be known that no separation or mortification is spiritual, because such spirits can never exist without bodies. Though the body should be taken away from them and mortified a hundred times in one hour, nevertheless, they would always acquire another much more noble than the former.[324]

Paracelsus indicates here that each time a body is 'mortified' it becomes more 'noble' or pure and, therefore, useful as a catalyst. Also, in keeping with Aristotelian theory, the relationship between matter and form is irreducible in that neither can exist apart from the other. Paracelsian alchemy, in seeking an elixir of immortality, proceeds from a faith in the possibility of a materially instantiated bodily resurrection—immortality on earth, rather than in heaven. At the same time, however, the presence of the body is a serious problem, because it generates waste.

Whether or not the remainder is useless waste or a catalyst for further transformations poses a thorny yet important issue for a meditation on the cultural status of the copy within the alchemical tradition. Unlike nature, humans produce substances that cannot be as easily recycled, or converted into something useful for someone or something else—like plastic for instance. As a result, the planet is quickly becoming a gigantic trash heap—a monument to human ingenuity in the form of diapers, foam coffee cups, and juice boxes. Similarly, alchemists puzzled over what to do with the stuff that is left over when a base metal is burned either slowly or violently, for days upon days. The status of garbage intersects with the questionable cultural role of technology. If technology were a semi-divine process of copying nature, then trash, the byproduct of mass production, ought to be recycled, digested or reabsorbed into the earth from

[324] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, p. 9.

whence it sprang. Yet, we know that all the stuff generated by industry is not so easily reabsorbed. Therefore, technology can just as easily be demonized, as alchemical practice was, as affront against nature and God; the profanity of artificial copies of nature, monstrosities that cannot return to the source because these things do not participate in the divinity of that source—but in the abjection of the sullied flesh of man.

The fear of technology is apparent on a number of different cultural planes and in several historical moments. The Luddite movement is one example, as is the cultural ambivalence surrounding industrial encroachment during the nineteenth century.[325] Recently, digital technology is the object of platitudes concerning the spectacular, violent, pornographic, and otherwise immoral attributes of a form of representation that heightens the possibilities of immersion and sensuous contact. Every new technology is the object of fear and scorn, not for the kinds of texts and meanings that it generates, but for the manner in which it reorganizes the experience of the viewer, user, or participant in ways that promote a questionable freedom in bodily engagement, which is more dangerous than the engagement of the mind merely. As with alchemy, the profanity of new forms of technological representation hinges on the magical manipulation of materials that violate the laws of the physical world and invite direct engagement in fantasy. The increasingly sophisticated means of accomplishing that illusion are hidden from the user.

For a long time, according to Paracelsus, learned men sought the means to prolong life. Implicit within his claim, is that their lack of success is due to the fact that they failed to copy natural law accurately. To achieve immortality, it was necessary to mimic the ways of heaven and adhere to the proper commingling of the elements, in order to achieve the perfect union of

[325] Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York: Oxford University Press, 1964).

body and soul, or substance and essence. As the alchemists purified base metals by submitting them to flame, Paracelsus, the student of medicine, sought a way to submit that body to a similar process of purification in order to extract the indestructible part of the body from the mortal part of the body. Paracelsus believed that this could be accomplished through the skillful extraction and creation of the indestructible essence of a metal—this essence was metallic, since such a substance is, according to Paracelsus, indestructible by fire. According to Paracelsus, human life could be augmented and extended through artificial means by using this essence as a catalyst. Only a substance that was itself resistant to decay could produce transformations in metals and in the human body. The alchemists tried to spiritualize earthly existence, and as a result, found fleshy bodies entangled in a physical and theoretical thicket. Although the goal was to refine the relationship between the body and the soul, it cannot be denied that embodied existence constituted a serious problem—a leaden heaviness that congeals around the pure essence. In a practical sense, the body is an obstacle that might be successfully submitted to more and more intense purifications. The mortification of matter is always accompanied by the seductive possibility of artificial transcendence in Paracelsian alchemy.

A substratum of cultural longings concerning mortality and transcendence congeal around attempts to artificially extend and mimic natural laws and processes. Can the artificial creations of humans not only improve upon nature, but also prevent the decay to which all natural things are subject? An analysis of alchemical rendering is a useful entry point into the historical basis for such cultural longings. Paracelsian alchemical practice shows us that, prior to the industrial revolution, scientists and philosophers speculated that immortality could be achieved through artificial means. Therefor, some of the same speculations that drive technological development today, also influenced the theory and practice of alchemy.

Alchemy as historical oddity and alchemy as conceptual glue resurrect issues germane to mass production. Specifically, alchemical history amounts to an extended reflection upon themes that continue to haunt media technology today—the relationship between the status of the real and the fake, the status of matter, the remainder and its concomitant themes of embodiment and mortality. Alchemical practice was just as enamored with the possibility of animating the inanimate as we are today. Lunenfeld had a hunch that alchemy ought to be studied in tandem with contemporary digital technology because alchemical practice is a prototypical moment in developing understandings about the nature of artificial extensions of the human body. But more importantly, at the level of practice, digital animation and alchemical conjunction are oddly similar. Both realms are interested in abstracting an essence from the body, purifying this essence, and then rejoining the body and the essence in an improved, yet transformed state. The paradox that is frequently observed in technological manipulation is that digital code seems to abstract completely from the physical realm, losing any recognizable correspondence to its referent. Yet it is nonetheless, much more "mercurial" as a medium, since it is fluid, it obediently takes the forms it is asked to take, it is more efficient and malleable. The alchemists also sought such a medium or catalyst for copying, not life itself, but lifelikeness.

> There is nothing at this stage which need delay the operator; only let him put before himself a fact which has been passed over by the philosophers, and by some studiously veiled, namely, that in projections there must be a revivification, that is to say, and animation of imperfect bodies—nay, so to speak, a spiritualization; concerning which some have said that their metals are no common ones, since they live and have a soul.[326]

The possibility of animating inert bodies carried with it the promise of bestowing god-like power upon the practitioner by bringing dead flesh back to life. This project was never abandoned, although it now appears in a more empirical and utilitarian guise. Paracelsian alchemical

[326] Paracelsus, *The Hermetic and Alchemical Writings of Paracelsus the Great*, 64.

rendering helps us trace the impressive endurance in the belief that immortality might be achieved through artificial means.

A theory of objects as the container of both body and soul, or substance and form, possesses explanatory power in a cultural moment that constructs technology alternately in utopian and dystopian terms. In the utopian narrative, technology promises bodily transcendence because our machines are not subject to death and decay. In the dystopian nightmare, technology renders human bodies obsolete. As such, alchemy, as an early form of technological augmentation, condenses and amplifies long-term cultural longings concerning the limitations of the body and linear time, and the human desire, ubiquitous in cultural myth and legend, to transcend these limitations through artificial and technological means.

5.0 CHAPTER 4
DIGITAL ALCHEMY: THE SECRET KINSHIP OF ANCIENT AND MODERN TECHNIQUES OF TRANSFORMATION

Science fiction films frequently use the latest technologies for their special effects while, at the same time, the themes of these films wax nostalgic about a more organic, if obsolete, past where human action is governed by direct and unmediated relationship to nature, pure mind, or "the force" unencumbered by technological enhancements. A classic example of this phenomenon occurs in *Star Wars*, when seconds before Luke's victorious demolition of the Death Star, the ghostly voice of his late guru advises him to turn off his targeting equipment and use his intuition to make the difficult hit. Despite its' ostensible message to reject technology, the film was created using innovative camera and computer technologies. Frequently, science fiction films are at the forefront of exploring new means of cinematic representation, while these films' themes posit a world in a dubious state of dependency on technology.

This chapter addresses this discontinuity in form and content by showing that this incongruity is the artifact of a historically and culturally grounded moral ambiguity surrounding all new media technologies. To that end, the chapter explores two films within the science fiction tradition that depict a division between their message and their formal architecture, *Final Fantasy* and *The Matrix.*

In the prior chapters, I examined the professional goals of digital realism and interface design in order to dispel ungrounded theorizing regarding the goals, achievements, and limitations of digital and virtual representation. Further, I outlined the goals of a professional

alchemist, Paracelsus. In both cases, present and past, I paid close attention to the practices that these professionals deploy to reach their goals and the language they use to describe their work. Using the films mentioned above, this chapter will bring forth these practices and concepts to argue that if we lack a language for addressing and critiquing the current metaphysical aspects of new media technology, alchemical practice provides a useful set of terms for understanding the cultural, material, and industrial process of material transformation and the role of technology in mediating that process. But more importantly, a theory of digital alchemy offers new insight into the perennial problem of reality and representation. This chapter uses the film *Final Fantasy* and *The Matrix* to ground these observations. Further, by explaining the goals in the making of these films and their critical reception, I will show how the language, practices, and goals of alchemical transmutation provide, not just an interesting parallel, but a persistent and largely ignored cultural and historical resonance to contemporary reflections on the role of materiality, technology, and representation.

I offer a sustained examination of the commonalities between contemporary practices and historical ones. For instance, Peter Lunenfeld claims that "cybernetics is the alchemy of our age: the computer is the universal solvent into which all difference of media dissolves into a pulsing stream of bits and bytes."[327] There are some general characteristics that alchemy and digital representation share. First, a set of complex and highly abstract terms bar the way for the uninitiated, ensuring that the 'craft' is one that builds incrementally upon the innovations of its forebears. Although it is true that interface design for animation programs is motivated by the goal of making the software easier to use, it currently remains a difficult process. A program like *Maya,* for instance, is replete with icons, symbols, menus, and all manner of functions that must

[327] Peter Lunenfeld, "Unfinished Business," in *The Digital Dialectic: New Essays in New Media*, ed. Peter Lunenfeld (Cambridge: MIT Press, 1998), p. 7.

be learned. As explained in the prior chapter, there are hundreds of books written on just this program alone. Each book deals with different aspects of the program, including character modeling and special effects.

Similarly, alchemical symbolism comprises an array of pictorial symbols serving as tools or techniques for different processes. Like interface iconography, alchemical icons for metals, planets, and processes, instantiate the actions associated with them. The iconic system, in both cases, is concrete and symbolic. Iconic controls afford the user contact with objects in the realm of the virtual. Yet these tools are also symbols of conventional operations in the real world. The animator places objects and models in three-dimensional space with the help of 'buttons' displaying such images as a cube, a hand, a magnifying glass, and a variety of three-dimensional shapes or polygons. Therefore, like alchemical symbolism, digital animation icons tend to collapse (cease to recognize a distinction between) representation and reality, the former refers to an elaborate language of icons and the latter to the concrete procedures that these symbols allow.

The relationship between real objects represented in unreal space has the effect of flattening our commonly held assumptions about the insoluable distinctions between the real and the fake. This makes sense since, as argued in Chapter 2, the goal of interface design is to render the relationship between concrete, embodied practices and technologies of representation transparent. Likewise, the relationship between the practitioner and the tools evokes alchemical processes because virtual space, like the alchemist's laboratory, assumes a co-extensive or transparent relationship between mind and body. Lev Manovich has rightly compared digital technology to the "modern trend to externalize mental life," and asserted that digital technology's relationship to old media forms is one that enforces "increasing abstraction."[328] In the rarefied and abstracted space offered up by the computer, pictorial symbols actually reach

[328] Manovich, *The Language of New Media*, p. 57.

further back than the nineteenth century because, yet again, they deliver information that is metaphorical and concrete. These images are meant to provide immediately recognizable instructions for the adept who is trained to understand the language. Alchemical and digital symbols, like traditional medieval iconography, retain the "essence" of the thing they represent—the symbol and the thing it is supposed represent are one in the same since, in both cases, they refer to concrete practices.

Another way in which digital production and alchemical transmutation are linked is in the fact that they are both crafts. "It will be apparent that the first alchemists found ready to hand a mass of technological knowledge and practice, much of it very appropriate to the operations they wished to carry out. At the same time they were innovators in the sense that they often considerably modified existing apparatus and appliances, and adapted industrial chemical processes to ends for which they were not originally designed."[329] This passage shows that alchemists used existing technologies and tweaked them to find new uses. My point here is not to celebrate both realms as 'artistic' (although they certainly are), but to show first, what is meant by the 'craft' of alchemy. In other words, alchemists were interdisciplinary in their approach to manipulating matter. They were frequently schooled in many different professions and like animators, were both left and right brained. They were craftsmen (dyeing, distillation, smelting), scientists (early chemists and physicists), physicians, scholars (translators of Arabic texts), mathematicians, astrologers, and priests—often simultaneously. Similarly, to be an exceptional (or even a moderately successful) animator, you have to know a little bit about widely divergent fields of knowledge—drawing, sculpting, graphic design, physics, film, marketing, computer programming (writing code), math, and geometry. We usually think of the scientific and technological fields as being highly specialized and isolated from the epistemological goals of

[329] E. J. Holmyard, *Alchemy* (New York: Dover Publications, Inc., 1990 (1957)), p. 45.

other disciplines. For instance, traditionally biology and chemistry are considered to be separate areas of scientific inquiry requiring specialized sets of techniques, skills, and procedures. Interestingly, alchemy is rejected as a science on the grounds that it failed to establish disciplinarity. In other words, it did not follow a strict scientific method because of its quasi-mystical attitude toward metals and chemicals. The fields of science, engineering, and technology now unabashedly admit that these mystical and creative approaches to their craft foster the cross pollination of ideas across disciplines. For instance, interface designers, as shown in Chapter 2, use metaphors like magic and theater to describe and translate the goals they have for end users. Practitioners of digital design realize that the seemingly incongruent realms of art, geometry, philosophy, theatre, physics, and biology are all necessary to the process of the simulation and replication of natural phenomena.

Therefore, on the levels of practice, representation, as well as metaphysical speculation, alchemical and digital production share many striking resemblances. The rest of this chapter is devoted to drawing connections between the goals and practices in each field, beginning with an examination of the successes and failures of the goal of realism in the film, *Final Fantasy.*

In the full-feature, digitally-animated film *Final Fantasy,* stunning achievements in photo-realism inspired disparate feedback. Reviews of the film are suffused with invective and disappointment that the film failed to deliver on its goal of portraying digital human actors that are indistinguishable from real humans. One critic asked for audience feedback after a screening of the film and obtained some strong opinions. “The group I went with couldn’t figure out why real actors weren’t used. We figured that with digital actors, you could do anything. We were stunned when they did nothing.” Another audience member adds that the film was characterized by “wooden, inexpressive characters who mouthed rubbish from a stupid script, and as they died,

I found I couldn't care less."[330] Overall, the comments expressed disappointment that the characters were so unconvincing, not just in terms of whether they looked real, but in terms of the audience's sense of identification with them. Other common reactions to the film included speculation on whether digital actors would eventually replace real ones. "These artificial characters will eventually replace live talent, mainly because of cost but also as a means of ensuring that what you want said gets said correctly."[331]

The film was a box office failure. It was produced for $115 million and yet made only $30 million from ticket sales. According to Barbara Robertson, it was the only computer-generated film to fail that year.[332] However, the box office debacle is possibly attributable to a marketing error. The film's guaranteed target audience was supposed to be young white males who play the video game. But the plot of the film bore little to no resemblance to the original game series. The gaming community was perhaps impatient with the themes of romance and ecological mysticism. Further, parents and children, hoping for an animated film in the vein of *Toy Story* or *Shrek* were confused by the adult themes. Apparently the film failed to find its niche. However, box office sales are only one way to judge a film's success or failure.

Digital animation professionals, on the other hand, marveled at the groundbreaking level of realism obtained in the human figures. Computer graphics professionals agree that it constitutes a watershed moment in animated film in that it comes closer to achieving a long-held industry goal of photorealism than any 3D film ever has to date. One critic admiringly says of the film, "*Final Fantasy* is nothing if not a labor of love. The time, care and craftsmanship put into

[330] Phil LoPiccolo, "But Can She Act?" *Computer Graphics World*, Sept. 2001, p. 4
[331] Ibid., p. 4.
[332] Barbara Robertson, "Feature Frenzy," *Computer Graphics World*, Jun. 2003, p. 12.

each character and scene is stupefying. Even the little things, like Aki's hair flying in the wind, strand by strand, are impressive."[333]

The design goals of the film were ambitious. However, working on tight budgets and time constraints animators, like most human beings, make due with efforts that often fall short of their expectations. Typically, once an innovation in rendering hardware or interface design is discovered, created, or stumbled upon, it is quickly abandoned in the ceaseless quest for greater levels of realism. "Animators are a discontented bunch. As soon as something gets simple, they make demands that get the whole thing complicated again."[334] The challenge of realism continually guarantees that digital animation is driven by self-defeating standards that are constantly going up and up. It seems that animators won't be satisfied until they can fool the eye completely. The film's producer explains, "I want the audience to feel as if they were watching live humans on film and not see anything unnatural about computer-generated characters."[335] As shown in Chapter 2, despite solid professional achievements in photorealistic representation, historically, the major hurdle for obtaining photorealism is the depiction of organic *imperfections*. In seeking the simulation of human movement, facial expressions, and surfaces like skin and hair, what animators (and alchemists) seek is the "*essence"* of lifelikeness. Says Remington Scott, the Motion Capture Director for *Final Fantasy*, "When characters are standing still and starting to talk and relate to each other, there are incredible subtleties and nuances . . . These things are the essence of what it is to be human, to move like a human."[336] A more realistic understanding of the challenges of modeling digital actors accurately echoes the industry literature. As we have seen, scores of conference papers are devoted to depicting human nuances,

[333] Tobey Grumet, "The Look of Fantasy," *Popular Mechanics*, Aug. 2001, p. 37.
[334] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 306.
[335] LoPiccolo, "But Can She Act?" p. 7.
[336] Barbara Robertson, "Reality Check," *Computer Graphics World*, Aug. 2001, p. 24

from muscle fatigue to the texture of hair. According to LoPiccolo, "the characters must acquire that elusive life force . . . and get beyond the point where an audience will focus only on their imperfections."[337] As a means of bypassing the problem of modeling naturally occurring phenomena, digital animators often rely on shortcuts to make passable copies.

The critical reception of *Final Fantasy* shows that, at least in one venue, the makers of the film failed to reach their goal of photorealism. For the most part, critics and reviewers judged the digital realism in the film to be a failure. "Noting that they tried to achieve a heightened reality in the film, not a replicated reality. *Final Fantasy* doesn't look exactly like reality, but it doesn't look exactly synthetic either."[338] One critic claims that *Final Fantasy*

> is an attempt to generate photorealistic images through CGI, creating animated characters as close to human as technologically possible. The characters look almost lifelike, but there are disconcerting differences in skin texture and movement that throw everything out of kilter, leaving viewers uneasily observing the animator's work instead of paying attention to the plot.[339]

But the film seems to have drawn a disproportionate amount of harsh criticism. Audiences are comfortable with digitally generated ogres and toys, but remarkably unsettled by virtual humans. One fear that is echoed again and again in the criticism is that people were afraid of being tricked by technology. "The problem with animated characters who look almost human . . . is that the slim margin of difference becomes really distracting. It's hard to stop looking at her [Aki's] hair, because it's so lifelike and perfect, with shampoo-ad bounce."[340] Also, audiences were, presumably, seduced by the technological novelty of the film and thereby distracted from its content. The issue of novelty however, lends a historical irony to the cultural reception of *Final Fantasy* since the appeal of novelty congeals around every new technology—until it becomes

[337] LoPiccolo, "But Can She Act?" p. 7.
[338] Robertson, "Reality Check," p. 24.
[339] Robert S. Rothenberg, "Inflation, Animation, Imagination and Exploitation," *USA Today*, March 2002, p. 72.
[340] "The Final Insult," *Maclean's* 2001, p. 46.

mundane. 'Novelty' is itself, a timeless concept since it reemerges with each new discovery with perennial certainty. "The temporal dialectic of the new as the always-the-same, the hallmark of fashion, is the secret of the modern experience of history."[341]

Some critics of the film, however, are just as likely to embrace a utopian view of its digital effects, thus underscoring the opposing poles of hope and fear that frequently surround speculation about new media. One critic posits that, as a result of the technological innovation showcased in *Final Fantasy*, "directors could then present anything they can imagine rather than having to work with the intransigent stuff of the real world."[342] Similarly, Gary Mundell, the Computer Graphics Supervisor for *Final Fantasy* claims that "we can do anything we want now. In this type of filmmaking, there are no limitations on special effects. There are no limitations on scenery. We can put a human character in any situation and make it do anything. There is no story that cannot be told."[343] This hopeful attitude toward digital cinema is also commonplace among professional animators. For example, one Maya expert asserts that

> Films are increasingly going digital for two main reasons. The first is that, in many cases, it is cheaper to create a virtual set in the computer than to build and shoot on a live set . . . It also is becoming cheaper to create computer-generated "settings" for large-scale fantasy or period films than it is to make them as full-scale live sets . . . The second reason why films are increasingly going digital is the control it gives filmmakers . . . The director has the power to alter the performance for whatever effect is needed if the performance is digitized into the computer and then placed onto a digital 3D character . . . The delivery of the performance, however, will increasingly be wrapped in a realistic digital skin.[344]

It is true that digital digital technology has granted the industry a certain level of elasticity and malleability in the filmmaking process. The creation of some scenes, creatures, and effects would

[341] Buck-Morss, *The Dialectics of Seeing: Walter Benjamin and the Arcades Project*, p. 293.
[342] Steven Poole, "Future Imperfect," *New Statesman*, Aug. 6 2001.
[343] Robertson, "Reality Check."
[344] Maraffi, *Maya Character Creation: Modeling and Animation Controls*, p. 4-5.

have been much more difficult to construct out of real materials like the huge crowds of aliens in the recent installments of *Star Wars*. But the generous praise quoted above is somewhat exaggerated, since it is clear that within the realm of professional animation, old problems are rapidly replaced by new ones and the goals of realism, as is shown in the film *Final Fantasy*, are constantly receding onto a horizon that is always just out of reach. Directors, designers, and animators are still forced to work with real world materials, such as the use of human actor's bodies in motion capture technology. In fact, some critics considered the use of motion capture technology excessive. "Every bit of walking, clambering and jumping was first done in a studio by stuntmen, so that the movements could be pasted wholesale on to digital skeletons."[345] Further, the design and implementation of animation software shows that these programs provide their own "intransigent stuff" in that each new innovation introduces more obstacles and challenges. In addition, audiences increasingly become accustomed to viewing digital effects and can spot it in a film without much difficulty. Audiences may even feel uneasy when viewing the uncanny images of humans that are not really "cartoons" but are not really human either.

Final Fantasy cannot be rejected on the grounds that it fails to provide a window onto reality, since no film can or wants to copy reality accurately. It is important not to confuse the goals of realism with reality, however much the traditional conventions of realism are being tweaked by contemporary digital design. Most audiences tacitly understand the rudiments of film conventions, even if unconsciously. These arbitrary and culturally conditioned rules that govern "the suspension of disbelief" allow audiences to enjoy a movie while knowing all the while that they are watching fiction and not reality. Therefore, explanations for the poor reception of the film must lie elsewhere. By what aesthetic criteria was the film judged? In what follows, I will make an explicit connection between the goals, processes, and subsequent reality of alchemical

[345] Poole, "Future Imperfect."

and digital representation. Alchemists and animators begin with ambitious goals but discover, through a process that demands compromises and shortcuts, that the real goal is always just out of reach.

Like Paracelsus, digital animators are driven to unlock the secret potential that lies dormant in matter by animating inert objects. Practitioners of digital animation also feel that their objects "live and have a soul." Both animators and alchemists approach the process in the hope of creating an artificial yet convincing copy of naturally occurring objects and temporal processes. In short, both alchemists and digital animators chase after the life force that animates all living things. Not surprisingly, the goal of realism, the "life force," is referred to using alchemical symbolism since it is a useful metaphor for describing an elusive goal. For instance, "the *Holy Grail* of no-compromise real-time film-quality photorealistic animation appears to be more than a mere pipe dream."[346] Further, "human faces will always be the elusive *grail*, given their complexity."[347] Similarly, Tony Feldman claims that in terms of the computer graphics industry "the *Holy Grail* remains the effort to deliver full screen, full motion at good quality resolution."[348] The Grail symbol is used frequently in alchemical symbolism since it refers allegorically to the golden chalice sought by Arthurian Knights, steeped in cultural and mythological lore. It is a common alchemical symbol or metaphor because it refers to a process of seeking gold as a two-fold reality of materiality and spirituality that is always just out of reach. The Grail is also associated in alchemical lore with the elixir of life or the fountain of immortality. It is no accident that the long-term association of technology with the augmentation of the human body extends from the alchemical techné of bodily transcendence. In other words,

[346] Em, "Siggraph 2003," [emphasis mine].
[347] Kaplan, "High Tech in Toon Town: Why the Computer-Generated Hit *Toy Story* May Change the Business of Animation Forever," [emphasis mine].
[348] Tony Feldman, *Introduction to Digital Media* (New York: Routledge, 1997), p. 27, [emphasis mine].

the origins for contemporary longings and fears concerning the ability of technology to improve and lengthen human life can be easily traced to a long held faith in the potential for alchemical magic. Watkins celebrates the innovation of NURBS in animation by stating that "This sort of flexibility is better than *gold* as you work with hard-to-master organic forms."[349] He is explicitly using gold as a metaphor for pliability, and implicitly using it as a metaphor for discovering the elusive secret of organic life. Digital realism is a process of seeking lighter, less computationally expensive, and hence more malleable models. "The most believable animation is the one that transcends the heavy technical requirements of animation to a level of organic movement."[350] Similarly, the process of obtaining gold is to burn away that heavy dross that congeals around the gold hiding inside. Therefore, digital animation and alchemical transmutation are linked by a common metaphysical problem—how to transcend material nature.

Because both digital and alchemical manipulation is driven by the goal of harnessing the animating life force, they engage in a similar process to reach that goal. Both alchemical and digital practice constitutes the manipulation of elements and composites of elements that inhere proportionally in larger objects. Manovich describes the smallest point in computer graphics, the "pixel" as an "atom." We can refer to computer language in physical, chemical, and atomic terms because new media objects are "modular." This means that digital media texts "can be accessed, modified, or substituted without affecting the overall structure of the object."[351] Since media texts are modular and can be expressed in layers or atoms, then each of these independent units can be rendered separately, which saves a lot of time.

As shown in the prior chapter, Paracelsian transmutation can be summarized as a repetitive process of purification through separation. Rendering parallels the alchemist's final

[349] Watkins, *3d Animation: From Models to Movies*, p. 35, [emphasis mine].
[350] Ibid., p. 3.
[351] Manovich, *The Language of New Media*, p. 31.

stage in transmutation, the "conjunction" or the union of opposites. The alchemist's goal is to reunite the purified materials into a whole that represents the perfect balance of matter and spirit. In alchemy proper, the conjunction is also referred to as a "wedding" of opposites. This union (which is also occurring simultaneously within the mind and body of the practicing alchemist) resembles the moment of truth in the final render. Like the alchemical process, rendering is an iterative, multi-layered approach to a material object that is undergoing a transformation in the hands of the practitioner. The alchemical procedure of separating and elevating the pure part of matter through sublimation, helps to explain the simultaneously embodied and disembodied event of transcendence. Both materially and metaphorically the recalcitrance of matter serves as an obstacle to transformation. This heavy matter must be burned away in order to produce a substance that is more malleable. Similarly, digital animators, using real world objects in the modeling process such as live actors, use motion capture technology to abstract from the flesh. Digital code is the analogical equivalent to the quintessence, the materially pure philosopher's stone that grants a magical malleability to inert matter.

In other words, algorthimic or mathematical representation is the key to unlocking, not just the appearance of realism, but the underlying laws that govern realistic movements and behaviors. The quintessence, the stuff left over after all this burning and processing, is a substance that is supposed to catalyze transformations in other objects, becoming a type of copying device to, presumably, make more gold. As we have seen, however, this goal remains out of reach. In both animation and alchemy, the conjunction, which is supposed to be the end, usually has to be repeated. As in Paracelsian alchemy, the transmutation process is performed over and over again to separate out the pure parts from the waste. Both alchemists and animators are concerned with the layers of materials necessary to produce the illusion of reality. Alchemists

intend to strip an object of its dead weight or "dross" while digital animators seek to add layers to the "essence" of their object, which starts out with a wire frame model or simple polygon. Digital animators put layers on in the sense that they add layers of skin, surface effects, and textures in separate stages. A good example of this layering technique occurs in a discussion of the making of one of the most celebrated scenes in *The Matrix,* the pods of unconscious humans.

> To create the fleshy realism of a fetus floating in a pod, Rudy Poot used a system he has been developing over the years that, uniquely, allows him to layer Renderman shaders together on one object . . . Thus, although the pod itself is one egg-shaped sphere, because of the rendering program, it appears to be a volume with realistic-looking tissue and mucus inside. The pods have four layers. You see the fleshy tissue on the baby refracted within, a layer of grimy bits, a mucus layer, and on top of that, a clear membrane.[352]

Ultimately, however, in both cases, the conjunction or final stage amounts to a union of perfected layers. In other words, both practices entail a desire to uncover the surface in order to discover the essence or secrets contained therein. Both practices entail uncovering the real, and subsequently rejoining the separate components that comprise organic and chemical reality. Like the alchemical conjunction, rendering is an iterative process. Alchemists are animators because they were able to give life to inert substances—but this life was virtual or, in other words, artificial. Both alchemists and animators got hold of a basic technocultural truth, that less matter produces more realistic movement because digital language captures and mimics the formal laws of movement (form) rather than merely copying the material substance of a thing. The paradox in the digital animation interface is that purely abstract digital code is translated by the computer into stunningly accurate three dimensional figures—that appear to be full of flesh (matter, content, substance).

[352] Barbara Robertson, "Living a Virtual Existence," *Computer Graphics World* 1999, p. 54.

Returning now to the case study, *Final Fantasy,* I will demonstrate another link between digital animation and alchemical transmutation. Due to the constraints placed on these practitioners by the artificial mechanisms at their disposal, both deploy short cuts as a means of getting around recalcitrant nature. Both digital animators and alchemists use shortcuts to make "passable copies" of a golden substance, the elusive life force which is thought to lie dormant in matter. "Alexandrian alchemists were not attempting to make gold artificially, but were merely trying to prepare passable imitations."[353] The many different shortcuts sought and deployed by animators shows that, like the alchemists, it is only important to achieve the appearance of gold or, in the case of the animators, the appearance of realism generated through a clever representation of surface effects like lighting and texture. Users can customize icon buttons to instantly "clone" objects they have already created. "If the user is animating an army of trolls, the creation of the troll's body can be assigned to an icon button and stored on a shelf."[354]

Animators and interface designers try to write algorithms that will result in plausible representations of real objects in three dimensions. Although the problems and obstacles faced by digital animators remain intractable, the goal of instantiating real-world flaws within digital representation has been attained to a certain degree. Animators have accomplished some of the most impressive results in digital realism by using shortcuts. "For the purposes of artistic rendering, it is seldom crucial that the shading be exact. It is more important that shading convey form, be descriptive of texture, and place objects within a scene in a common context."[355] One of these techniques is motion capture technology. Motion capture technology "refers to precisely recording the position and movement of an actor so you can later apply that motion to a digital

[353] Holmyard, *Alchemy*, p. 41.
[354] Avgerakis, *Digital Animation Bible: Creating Professional Animation with 3ds Max, Lightwave, and Maya*, p. 217.
[355] Gooch, "The Lit Sphere: A Model for Capturing Npr Shading from Art," p. 144.

figure's skeleton."[356] Nevertheless, in the absence of from-the-ground-up-modeling, motion capture using real humans is the best way to simulate the minute movements and gestures associated with "humanness" despite the fact that some critics of *Final Fantasy* considered it 'cheating.'

However, far from copying the real, the moment of rejoining separate layers results instead, in seeking artificial shortcuts around the difficulties of mimicking natural processes. In other words, both alchemy and digital animation are strongly characterized by a blurry distinction between surface and essence that guides and places restrictions on the process of material transformation. Both question the necessity of appearance versus the potential inauthenticity of not attending to the interior. In alchemy, obtaining the appearance of gold amounts to trickery while in digital animation, short-cuts are often deemed to be a type of cheating. The obstacles to the process of obtaining either gold or realism, however, dictate that technologies of mediation that are intended to skirt the problem of accessing reality directly, instead only provide the illusion of reality. The important link between the two practices is that both recognize a relationship between essence and matter and seek to manipulate that relationship in an endless process of purification or abstraction.

The consequence of these seemingly endless steps is a receding goal. Both parties find the goal of the artificial replication of reality to be extraordinarily elusive as the prized realism slips further and further onto the horizon. Similarly, new technological possibilities create new problems for animators. Further, like persecuted alchemists of old who failed time and time again to make authentic gold versus passable copies, digital wizardry is suspicious on the grounds that it uses magic to trick and seduce the eye. The seduction of the image is also a

[356] Masson, *Cg 101: A Computer Graphics Industry Reference*, p. 118.

commonplace critique in academic visual studies.[357] The process of reaching the goal of realism generates ever more impossible standards of realism in the field of digital animation.

The residual effects of this iterative process are instantiated materially in its artifacts. In other words, the leftovers or waste generated by the alchemist's purifications is a material byproduct of the attempt to replicate natural laws. Similarly, digital texts like *Final Fantasy* are haunted by the ghostly traces of organic life, which visually signal their inauthenticity. Theorists of new media have explored this connection between digital representation and disembodied voices that signal the death of organic reality. According to Margaret Morse, "Cyberspace, beyond its business uses, can invoke a parallel and sometimes a transcendent or spiritual world that revives the dead or the spirits of things in the limbo of the possible. Just as the mysterious telegraph and the telephone were also once thought able to contact the other world, cyberspace is also an underworld in which to meet one's Eurydice."[358]

In terms of *Final Fantasy* and other renderings of digital humans such as those occurring in video games, Benjamin's theory of aura explains why these images are met with dubious praise. One critic of the realistic portrayal of humans through digital technology claimed that these figures were merely "pixellated ghosts of human movement."[359] The aura of inauthenticity surrounding digital representation is intimately connected to the metaphysics of photo-realism. One critic derides the producers of the film by stating that "In the most audacious jest of all, *Final Fantasy* even hangs it plonking boiler-plate space-opera on the philosophical question of whether the earth has a soul or a spirit . . . a film entirely without humans exploring the essence

[357] Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth Century French Thought* (Berkeley: University of California Press, 1993).
[358] Margaret Morse, "*Nature Morte*: Landscape and Narrative in Virtual Environments," in *Immersed in Technology: Art and Virtual Environments*, ed. Mary Anne Moser & Douglas MacLeod (Cambridge, MA: The MIT Press, 1996), p. 206
[359] Poole, "Future Imperfect."

of humanity."[360] Unwittingly, Mark Steyn expresses the paradox between authenticity and artificiality that is central to digital and alchemical representation. *Final Fantasy* is judged, not according to standards of realism, but according to deeply held, enduring fears about the relationship between humans and technology. Since digital actors merely convey the aura of real humans, digital representation, like so many mediation technologies before, signals obsolescence, decay, and death. We may excuse critics of *Final Fantasy* for being innocent of scholarship on analog film and photography which have also made claims to exact replication of the world in its early years. These mechanisms of mediation share much in common with digital representation and interface design. The more realistic digital representations appear, the more stringent our expectations become and the more virulently audiences and critics reject artificial copies on the grounds that they portray the mere 'ghost' of humanity.

Not surprisingly, digital representation is at the heart of ethical speculations about the feasibility of replacing human actors. The critical assessment of *Final Fantasy* reveals that the cultural role of artificial simulation is shaped by a number of complex forces including, cultural ethics, economics, industry standards, the psychology of the uncanny, and aesthetics. Even though it is clear that realism does not function as a one-to-one relationship with reality, digital animators, critics, and audiences continue to fetishize transparent realism, despite overwhelming obstacles.

A theory of aura then, is a useful conceptual tool for understanding the production and reception of digital texts. It also echoes the metaphysical ruminations of a group of new media scholars in explaining how the temporal logic of technological production produces social unease. As a "mechanical" device implicated in the aura of digital representation, the interface harbors similar metaphysical goals. As a tool that mediates dynamically between the promise of

[360] Mark Steyn, "Final Fantasy: The Spirits within (Review)," *The Spectator* 2001, p. 39.

bodily transcendence (the idea that technology will release us from the prison of our flesh) and the reality that we live in the world of dross, excess, and garbage. The professional, cultural, and metaphysical aspects of the interface are similar to those of the philosophers stone or quintessence. This is a substance that weds formal, and material substances, with spirit as a means of catalyzing transformations in other things. Like the interface, it is a tool for mediating between the body of the practitioner and the transcendent universal laws he or she is attempting to realize in the laboratory.

The following section uses *The Matrix* to explore and ground theories of interface design and the metaphysical speculation that accompanies them. This wildly successful film posits a context in which the characters shuttle between the world of illusion and the world of reality by using an interface as a portal. By downloading their consciousness into the matrix, the characters in the film leave their bodies behind and experiment with the fluid laws of physics in the world of the matrix. Within this illusory world, the laws of physics are transcended and broken since the digital realm affords a type of golden malleability. As in alchemical transformation, the state that is sought is a type of earthly transcendence: the ability to bypass the limits of materiality, while still remaining coiled within a mortal shell.

Unlike *Final Fantasy*, the *Matrix* films were extraordinarily successful on a number of levels. The films generated substantial box office revenue, but also stimulated the publication of scores of scholarly books and articles. *The Matrix* films were originally conceived of as a trilogy, including *The Matrix, The Matrix Reloaded,* and *The Matrix Revolutions*. In addition, a collection of animated shorts, *The Animatrix,* explains the historical origins of the Matrix by telling the story of the war between humans and machines. Therefore, although the first film is the most crucial in establishing the philosophical and metaphysical themes of the entire series, an

analysis of *The Matrix* alone is necessarily incomplete. Scholars have regularly identified the glaring mythic structure of the narrative which generally follows a classic pattern: 1. Hero is a regular guy. 2. Hero is initiated and becomes more than human. 3. Hero dies and is resurrected. 4. Hero destroys the enemy and redeems society. In what follows, I will describe the scholarly treatment of this film, as well as provide a brief reading of my own consistent with the argument of this project.

In terms of the overall plot structure of the films, the first film introduces a rather doubtful messiah figure, Neo who is quite ordinarily human except for his skills as an expert computer hacker and the presence of a question that haunts him like a "splinter in his brain." This question is, "What is the Matrix?" In this segment of the trilogy, Neo is literally 'born again' from the primeval goo of the machine womb and flushed unceremoniously into a stark reality whereby humans barely manage to outmaneuver the machines that are constantly looking for them. The first film ends with a resurrection scene, when Neo is brought back to life after being shot, to display physics defying mastery over objects in the Matrix. The second film treats the newly baptized hero beginning his struggle with his enemy and finding his true path with the help of the 'oracle,' a figure that provides much needed advice and assistance to the hero. The second film ends with yet another material transcendence that parallels the end of the first film. However, at the end of *Reloaded*, Neo gains mastery over the objects (the sentinel machines) that are chasing the humans in the real world (the world external to the Matrix interface). Neo is increasingly adept at shuttling between real and virtual worlds. Although in terms of the film's logic concerning the powers of mind over matter, it makes sense that Neo can accomplish anything (flying, leaping from tall buildings, running up walls, slowing down time) within the Matrix, we find that Neo possesses similar powers in the real world as well. Ultimately, he can

move in and out of the Matrix without the aid of being "jacked in" electronically (downloaded into the Matrix). In the last film, *Revolutions*, true to his role as the standard hero, Neo gives his life in exchange for an end to the war with the machines—a peaceful truce bought by his promise to eliminate a computer virus (Agent Smith) that is growing out of control and threatening both humans and machines. All three films present a irresistible hermeneutical puzzle that invite the unraveling of enduring philosophical questions albeit in contemporary technological garb.

The most provocative theme introduced in the series of films that comprises the world of the Matrix, is that what humans assume to be solid reality is actually a computer-generated simulation that keeps the mind active while the body is used as a battery to fuel the world of the machines. In a particularly unsettling digital representation within the film, vast fields of humans encased in womblike pods are depicted powering up enormous electrical towers that stretch in seeming unending fashion, off into the distance. The sickening state of passivity as well as the utter destruction of cherished individuality vividly isolates issues central to the history of humans and technology. The film smartly feeds upon the long-held fear of human obsolescence in the face of the very machines designed to make our lives better.

The protagonists who fight the machines have discovered a way to shuttle back and forth between the illusory world of the Matrix and the real world, a desolate landscape of the former human world, destroyed in the final war with the machines. A central theme in the film is the representation of the Matrix as an interface that functions as a means of transportation. Characters are "jacked" in through a plug in the back of their heads, and downloaded into the Matrix, while their bodies lie suspended on a ship in the real world. What is important about the film for this study is that it is both a cultural representation and an example of technological production. The film echoes discussions that take place in a variety of contexts (professional,

academic, and popular), concerning the role of the interface in transforming the relationship between the body/mind. But just as importantly, this film is celebrated for its rendering of cutting edge special effects. Further, these two aspects of the film stand in an ironic juxtaposition to one another because the film uses technologies like virtual camera in its production techniques at the same time the film's themes warn against the dangers of technology, i.e., potential enslavement by the very technologies designed to enhance human life.

As I will show in this section, academic treatments of the film become entangled in this incongruous relationship. In other words, they reproduce the very longings and fears concerning new technologies that the film so effectively critiques. Most critics either eschew or ignore the film's production and instead, reinforce the moral and ethical themes treated with extreme ambiguity in the film. In addition to the film's cutting edge special effects however, one of the reasons for the film's wild appeal is that the *Matrix* alludes to American archetypes that are immediately accessible to its audience; some of these include, *Alice In Wonderland, The Wizard of Oz, Sleeping Beauty,* classic American iconography of the Western 'showdown,' and a comic book aesthetic. The film cleverly combines new and old to provide a rich supply of hermeneutical puzzles for scholars of media, technology, film, communication, education, and philosophy.[361]

The ability to control, manipulate, and transform 'the real' takes place in *The Matrix* on both a thematic and technological level. Like many dystopian narratives within the cyberpunk and science fiction tradition, the world of the Matrix depicts a karmic reversal of fortune whereby the machines that humans made in an attempt to transcend bodily limitations ultimately

[361] Stephen Faller, *Beyond the Matrix: Revolutions and Revelations* (Chalice Press, 2004), Karen Haber, Ed., *Exploring the Matrix: Visions of the Cyber Present* (New York: St. Martin's Press, 2003), William Irwin, (Ed.), *The Matrix and Philosophy: Welcome to the Desert of the Real* (Chicago: Open Court Pub. Co., 2002), Matt Lawrence, *Like a Splinter in Your Mind: The Philosophy Behind the Matrix* (Blackwell Pub., 2004), Glenn Yeffeth, Ed., *Taking the Red Pill: Science, Philosophy and Religion in the Matrix* (Dallas, TX: BanBella Books, 2003).

guarantees the obsolescence of human flesh. *The Matrix* foregrounds thematically what its technological architecture performs concretely. Given this ironic juxtaposition of text and technology, it is surprising that the scholarly treatments of this film bypass issues concerning its production. Many theorists of *The Matrix* focus on the content of the film as a metaphor for contemporary cultural or psychological conditions (i.e., treating the film as text) and bypass the film's status as an artifact of technological production. In this section I will show that there is a gap between the scholarly treatments of *The Matrix* and the trade literature about *The Matrix*, in that the former is concerned with the meaning exclusively, while the latter is preoccupied with 'cool special effects.' I will argue that that both of these perspectives are incomplete because they both fail to acknowledge the symbiotic relationship between text and production in this film in particular.

Like the preceding section of this chapter, I will bring forward alchemical concepts with which to analyze the metaphysical issues raised in the production of the film, offering an alternative way to understand the cultural import of this cultural artifact. In an important way, the film is both about interfaces and is itself a type of interface, in terms of much of its digital architecture. While scholars are interested in the technological themes within the content of the film, another group (the younger generation to which the film appeals who are well schooled in technoculture) are interested in how the film was made. How then, should we read or interpret these films?

I offer an alternative way to approach this problem by bringing forward alchemical concepts concerning embodiment and transcendence addressed in Chapter 3. This analysis coalesces with a sustained examination of the digital alchemy of the interface, both in terms of

digital industry standards, as well as its role in shaping the critical reception of a cultural artifact that stimulated much discussion about the relationship between technology and humans.

Scholarly interest in *The Matrix* can be grouped into several categories; archetypal or mythic, post-structuralist or postmodern, and psychoanalytic. Rushing and Frentz examine the mythical elements of the film, ultimately concluding that the technical aspects of the film, the "dazzling special effects," detract from the potentially redemptive features of the archetypal hero-quest narrative. According to them, there is a fundamental incongruity between the thematic and formal levels in the film. Rushing and Frentz argue that the timeless theme of the hero-quest in the film's narrative is submerged by special effects that glamorize technology. "*The Matrix* is caught in the tension between its spectacular effects and its mythic tale of heroic initiation just as postmodern humanity is caught between its attraction to and its repulsion from its technological extensions."[362] The problem, however, occurs with the unexamined assumption that technological features are linked to gratuitous violence and puerile masculine representations of femininity. Further, they are disappointed that "mythic insights into the postmodern condition often come wrapped in visual images of spectacle that deny the very insights the narrative is trying to convey."[363]

Similarly, Scott Stroud argues that the hero-quest narrative commonly applied to the film should be modified to account, ethically, for the hero's destruction of community in order to save it.[364] He tries to update or modernize the hero-quest archetype examined by Rushing and Frentz by claiming that his "research approaches *The Matrix* with the purpose not only of critically examining this film and its implications, but also seeks to explicate a modern technological hero-

[362] Rushing, "Mother Isn't Quite Herself Today: Myth and Spectacle in the Matrix," p. 67.
[363] Ibid., p. 67
[364] Scott R. Stroud, "Technology and Myth Narrative: *The Matrix* as Technological Hero Quest," *Western Journal of Communication* 65, no. 4 (2001), p. 417.

quest that resonates with audiences in contemporary societies."[365] Stroud emphasizes the problems raised by a mythical analysis by arguing that a critique of the archetypal components seeks a universal explanation that necessarily bypasses a more varied and heterogenous account of culture. Stroud identifies two modern audiences that are alienated by *The Matrix* narrative, those who do not use technology and are therefore intimidated by it and the ultra-initiated, over-users of technology, the hackers. Both of these audiences are defined in terms of their relationship to contemporary technology. He argues that "the concerns of these groups within the modern audience must be present in the technological hero-quest in order for it to garner wide-spread support."[366] Ultimately, after a textual analysis of scenes in *The Matrix*, he finds that unlike the traditional heroes in conventional myths, Neo fails to return to society with the "boon" that will transform and redeem it (although, this does happen in the final installment of the series).

Although Stroud appropriately re-examines the technological features of the film, his treatment is nonetheless confined to the representation of technology within the film. He concludes, along with Rushing and Frentz, that the technological aspects of the film are morally suspect by stating that "This continual ontological separation leads to one dangerous narrative of 'solitary enlightenment; that is available in technological hero-quests such as *The Matrix*. This mythic lesson risks potentially dangerous transmission of action-guiding maxims to audience members."[367]

As is common in the literature, scholars approach the film's portrayal of technology as a question of value. In other words, is it good or is it bad? The film itself, however, is sophisticated enough to trouble these questions and leave them unanswered. It is clear that the technology is

[365] Ibid., p. 417.
[366] Ibid., p. 424
[367] Ibid., p. 437.

both good and bad in the film. Accusations of violence wrapped in sexy garb aside, the great majority of scenes establish the celebrated philosophical and metaphysical aspects of the film. For example, there are nine scenes devoted to conversations between Neo and Morpheus, or Neo and the Oracle that explore the nature of reality. Further, there are eleven scenes that deal explicitly with the metaphysics of traveling through the Matrix interface. Although I do not wish to argue that the number of scenes not devoted to violent themes diminishes the ambiguous ethics of those that do involve killing and death, I want to point out here that these scenes tend to overwhelm the 'smarter' aspects of the film or at least, those scenes that merit special attention as speaking directly to our contemporary entanglements in the culture of digital technology.

Post-structuralist accounts of the film attend to the overt reference within the film itself to Baudrillard's theory of simulation and the play upon his quote concerning the "desert of the real" which is uttered by one of the main characters. Williams uses Baudrillard's theory of simulation to argue that the makers of the film, the Wachowski brothers, conflate reality and simulation through a 'series of inversions' from which Trinity, the female protagonist, emerges as the real hero of the mythic quest. Rather than merely serving as the stock love-interest for the hero, she is the magical third element who shuttles masterfully between simulation and reality. She is the princess that wakes the prince from his sleep with a kiss. Trinity exemplifies the elasticity of the supposed real/fake binary. "By making reality itself malleable and adjustable to the human will, they have embraced hyperreality in its purest sense."[368] Surprisingly, Williams' treatment of simulation leaves the issue of special effects in the film unexamined. A character becomes the link between the two worlds, rather than a technological device.

[368] Christopher G. Williams, "Matering the Real: Trinity as the "Real" Hero of *the Matrix*," *Film Criticism* XXVII, no. 3 (2003), p. 15.

Chad Burnett also argues in a poststructuralist vein, that the "late 20th century has become exactly what the aesthetic of cyberpunk predicted; a world where the subject is forgotten, the flesh is burdensome wetware."[369] Burnett correctly identifies the centrality of the body in a film that thematizes the ability to meld mind and machine with the help of digital technology. Using Jameson's theory of "ontological shock," he argues that "the film acknowledges that it has all been done, consumes the past, and puts it in front of the audience avoiding false innocence while flourishing in its self-conscious consumption."[370] Again, his language is imbued with moral tones and the express concern that the film is depicting a world that offers false promises of technological transcendence. "Perhaps the most engaging and seductive line of thinking throughout the Wachowski brothers' film is the possibility that at a sensory level, virtual reality is far superior to physical reality."[371]

A lingering pessimism regarding the high-tech violence in *The Matrix* pervades the analysis of Jennifer Daryl Slack. Employing a Deleuzian methodology of "the logic of sensation," Daryl Slack offers an explanation of the film in which she will "come to know how adolescence is a kind of movement in relation with other bodies and that it has particular capacities to affect and be affected."[372] She concludes that *The Matrix* is complicit with the production of apathy since its lessons (i.e., its representations) include layers of sensation that potentiate such social ills as "passive non-learning, boredom, lack of enthusiasm, suicide, and the killing of school students and teachers."[373] The Matrix is conceptual glue connecting what she argues to be profoundly embodied states. The themes that the film conveys, killing with

[369] Chad P. Barnett, "Reviving Cyberpunk: (Re)Constructing the Subject and Mapping Cyberspace in the Wachowski Brothers' Film, *the Matrix*," *Extrapolation* 41, no. 4359-374 (2000), p. 361.
[370] Ibid., pp. 363-364.
[371] Ibid., p. 371.
[372] Jennifer Daryl-Slack, "Everyday Matrix: Becoming Adolescence," in *Animations (of Deleuze and Guattari)*, ed. Jennifer Daryl-Slack (New York: Peter Lang, 2002), p. 11
[373] Ibid., p. 12.

indifference, distance-learning (uploading a karate program directly into the brain), and labor performed by the machine are dangerous messages for a teenage audience. She concludes that "my belief that this logic provides a 'resting place' for many others, particularly teenagers, is strengthened for me each time I hear the details of a new school shooting, listen to the struggles of other teachers, or carry on a conversation with a young drug user."[374] While Daryl Slack is not explicitly blaming *The Matrix* in a simplistic sense for anticipating or provoking violent acts, as well as apathetic non-acts among teenagers, she does implicate the film in a manner similar to other scholars. The film provides violent images and questionable attitudes toward technology.

I do not wish to argue that the film does not evoke themes of violence, it should be clear that *The Matrix* is not unique in this sense. Historically, everything from the written word, books, newspapers, television, and now video games are charged with corrupting unsuspecting grownups and impressionable youths. In other words, we gain very little insight into the cultural importance of this film in particular by approaching it with questions of value versus questions of fact. However, I am referring to rhetorical and philosophical categorizations, not to empirical realities when I use the term 'fact' here. Questions of fact involve asking, what is the film about? Whereas, questions of value pose the question, is the film good or bad? The overwhelming majority of scholarly approaches to *The Matrix*, similar to reactions to *Final Fantasy* by the lay people, are motivated by questions of value or morality. And while both of these hermeneutic techniques are valid ways to read a text, the problem is that they are elided most of the time. Instead of a sense of reflexivity regarding one's reading, we are asked by the author to accept unquestioningly that the text should be read in such a manner. In this way scholars and film critics alike reproduce the moral dilemmas addressed in digitally-produced films, rather than

[374] Ibid., p. 27.

plumb them for their cultural import. Also in this manner, critics tend to focus more on the themes of the film and less on the techniques that went into its production.

Part of the reason for the interest in the film's themes is that *The Matrix* also provides rich fodder for psychoanalytic theory since it is replete with suggestive mirror images and bodily transport through 'portals.' There is also an interplay between minimalist post-apocalyptic machines and the abject gooey womb or "pod" where humans are cradled in unknowing oblivion while their life essence is sucked out by the machines. The status of the body, whether or not it is baggage, waste, or offers potential redemption for humanity, is a pressing issue in the film that invites critique. As we have seen, critics of the film frequently note this interplay of dialectical opposites, inside versus outside, body versus machine, illusion versus reality.

Zizek, for instance, argues that a moment of reversal occurs between the ontological status of wakefulness versus sleep. The real fantasy that sustains the 'freedom' of wakeful consciousness in the film (the virtual realm) is the dream of passive imprisonment in the womb. The two aspects of perversion are actually "on the one hand, a reduction of reality to a virtual domain regulated by the arbitrary rules that can be suspended; on the other hand, the concealed truth of this freedom, the reduction of the subject to utter instrumentalized passivity."[375] In other words, the really unpleasant reality is being awake, and the fantasy is passivity. Therefore, the logic of the film, which shows that humans are imprisoned by the machines unknowingly and must be released, actually conveys the subconscious truth of the human species for womblike security and non-identity. Zizek makes no mention of the role of technology in mediating this relationship, either in terms of the ostensible themes or formal architecture.

Similary, Rufo uses the Lacanian mirror stage to argue that the scene in which Neo passes bodily through the mirror in order to be reborn into the real, is crucial to the meaning of

[375] Slavoj Zizek, "The Matrix, or Two Sides of Perversion," *Philosophy Today* 43 (1999), p. 12.

the entire film. He claims that it "provides the gateway between the bondage of simulation and the advent of real subjectivity."[376] Although he does not explicitly refer to the mirror image in the film as an interface, his description of it as a medium or mode of transport in Lacanian terms is clear, since it differentiates between interior and exterior states. The interface is a point of connection that hinges two worlds, a boundary or barrier, and a means of transgressing that boundary. In fact, "the subject is always already mediated" between self as unified internal construct and self as an external object.[377] Again, this dialectical movement from inside to outside, between the real and the fake is a major theme in a film that foregrounds ontological and metaphysical themes of mind and matter. Rufo usefully applies Lacanian theory of "organic insufficiency," a concept laden with significance in a world of machines which are presumably superior to the human body. Rufo argues that Lacan's theories have to be reformulated for the audience of the 1999 film since, as a cultural artifact, the film represents a unique moment in imaging an age of technology.

The idea that digital and virtual technology has ushered in issues that are not amenable to traditional critical methods is common in the literature. Critics of the film usually seek new tools with which to tackle this unprecedented text. Rufo claims that the film's ubiquitous use of mirror images "has no resemblance to the totemic formulations offered by Lacan 50 years before,"[378] because now, both real and imaginary registers collapse into the symbolic. Also, Rufo dismisses the technological production of the film and focuses his discussion of the special effects on how it alters Lacanian concepts. "While the technological advances required for such a depiction are noteworthy, what is so remarkable about bullet time is that it converts the Lacanian real (which

[376] Kenneth Rufo, "The Mirror in *the Matrix* of Media Ecology," *Critical Studies in Mass Communication* 20, no. 2 (2003), p. 118.
[377] Ibid., p. 126.
[378] Ibid., p. 129.

cannot be represented by the symbolic) into the imaginary; audiences see the concentric waves of force produced by the bullet's path through the air."[379] Rufo closes with the familiar warning, that the film fosters the hope that one can use technology to discover this hidden essence and thereby transcend the symbolic world. He states, "the same dream at work in many of those who seek immortality through uploading their minds to computers . . . is an escapist and utopian technophilia, a vision of the subject that taps an unlikely, mysterious human essence through technology."[380] Predictably, the strangeness of this discovery is submerged immediately beneath a warning about the dangers of holding such utopianist attitudes toward technology. To my mind, however, the very idea that technology potentiates redemption is precisely what warrants closer investigation. Rather than immediately foreclosing that utopian attitude as naïve, however, we should seek to understand these cultural longings on their own terms. Especially since scholars themselves are not immune from a sense of ambivalence over the status of technology as a thematic element in science fiction films; and who often rehearse the same ambiguities in their own scholarship that are likewise prominent in the text they are critiquing. These investigations into the meaning and cultural relevance of *The Matrix* do not get us an explication of the cultural role of technology but a warning not to be taken in by those technologies. The twin myths of technological demons and technological redemption are nested together in this film. But this tension charged clash between irreconcilable modes of representation is not a problem to be overcome, but a depth to be excavated for its cultural lessons about technology.

Not surprisingly, scholars attend to the social impact of the film by interpreting the meaning of *The Matrix*; while the trade literature surrounding the making of the film reflects an interest in the technological architecture of the film. The authors of articles about the production

[379] Ibid., p. 135.
[380] Ibid., p. 138.

of the film are almost exclusively interested in the mechanisms for producing the special effects, lingering over the complex details of digital design. Several articles in *Computer Graphics World* for instance, meticulously list all of the software that was used to render the most innovative effects used in the film. Some of these include, Renderman by Pixar, Maya by Aliaswavefront, Soft-Image out of Montreal, Kodak's Cineon software for compositing, and Softimage Mental Ray shaders.[381]

Three techniques used in the film warrant special attention here since, like most digital design, each comprises a way to simulate and tweak the laws of physics. First, the technique celebrated in popular journals referred to as "bullet time," depicts temporal deceleration to the point that the audience can watch bullets streaming slowly through the air, trailing a liquid-like arc of atmospheric disturbance.

> The first Matrix introduced Bullet Time, the process that allowed us to see Neo outfoxing his opponents in super-slow motion. In Reloaded, which has some 1,000 virtual-effects shots (compared with 412 in the first film), special-effects supervisor John Gaeta trumped that effect with such devices as Universal Capture (putting five high-definition cameras on an actor so he can be duplicated or, in Agent Smith's case centiplicated, and shown from any angle, as in the Burly Brawl) and Virtual Camera (which can give emotion, anime style, to elements like fire and water). The idea was to make the effects so dauntingly sophisticated, says Silver, 'that people can't just rip us off again.'[382]

The second technique is virtual camera. Virtual camera produces the illusion of a camera capturing physically impossible or difficult shots. This effect is created by a computer and not a real camera. One such technique involves a camera whizzing around the characters in a smooth 360 degree swirl. Virtual camera makes use of motion-capture machinery. Although this technique was not invented by the film's engineers, they nonetheless boast that they have

[381] Robertson, "Living a Virtual Existence," p. 54.
[382] Richard Corliss, "Unlocking the Matrix: An Exclusive Look at the Year's Most Avidly Anticipated Film Epic," *Time*, May 12 2003, p. 5.

perfected the art of creating a "perfect" virtual look-alike of a real flesh-and-blood actor. In short, bragging rights are proportional to the levels of realism attained.

> Virtual cinematography wipes out the line in the sand between what is real and what looks like the work of a computer. Obviously, only one of those Agent Smiths is the real actor, Hugo Weaving—but you won't be able to tell which one. The other 99, all digital creations, are three-dimensional, photo-realistic copies. They're not just close approximation. They're perfect. Their hair ripples, their faces contort, their bodies twist and fight . . . 'The refreshing thing about virtual cinematography is that it starts out with the genuine article. 'We try to base everything on real actors and real objects,' says Gaeta.'[383]

What is important is that, far from being peripheral scenes necessary to wow an audience with gratuitous violence and action, these special effects are central to developing the themes of the film. This is a film about the manipulation and control of material reality and physical laws that uses interface technologies to manipulate these very special effects. The hero, Neo, learns to control these laws in the Matrix as he comes to understand that it is controlled by the mind, and material laws can therefore be bent and broken.

I contend that the rendering of these special effects using sophisticated animation interfaces like virtual camera is the key point at which the production and meaning of the film are indissolubly wedded, and exclusively textual analyses miss this conjunction between the materiality of production and textual representation. The effects of temporal decelerations and simulated human actors connect the ironic divide between a movie that is about surrendering our bodies to technology and yet uses that same virtual technology to tell the story. According to one reviewer,

> ironically, to make this movie, the Manex effects teams used machines to create new tools that make it easier to . . . create virtual realities and to render images that come closer to depicting

[383] Devin Gordon, "The Matrix Makers: One Year, Two Sequels--and a Revolution in Moviemaking."" *Newsweek*, December 30 2002, p. 80.

> real human tissue than ever . . . So the creators of *The Matrix*, a movie about a phony world in which it's impossible to tell the real from the fake—can now create cinema in which it's impossible to tell the real from the fake.[384]

While I could certainly point out the ways in which the goals of photorealism are also operable in *The Matrix,* I will consider the way in which this film thematizes the interface, by comparing the industrial and professional practices of interface design in Chapter 2, to its popular and cultural rendering in film.

There are numerous scenes within *The Matrix* films that have merited scholarly attention. I will focus on those that figure the Matrix itself as an interface or portal that allows transportation between two worlds, the real and the illusory. Just in case we were in doubt as to the importance of the interface as an important technological medium in the film, we are constantly reminded by the all-pervasive presence of screens. Screens are depicted inside Morpheus' ship and antique media devices are shown in an old warehouse including a television and phone. Mirrors of all kinds appear in the world of the Matrix, from the stylish reflective sunglasses used by the protagonists to side-view mirrors on vehicles like Trinity's motorcycle. In fact, the first scene viewed by the audience (on the film screen) is the scrolling green lines of digital code that the audience will come to learn, signals entrance into and out of the Matrix. This proliferation of screens at the level of representation, prominently underscores (in fact reflexively points to) new media technologies used to make the film. The status of the body and its relationship to technology is foregrounded again and again within the various installments of the world of the Matrix.

Neo's famous ride "down the rabbit hole" is depicted in a scene that has drawn a lot of critical attention—the mirror scene. After downing the ominous "red pill" that will irrevocably

[384] Ibid., p.80.

alter his life by allowing the folks on Morpheus' ship to locate his body within the vast fields of human pods, Neo touches the glass mirror within a room in an old building generated by the Matrix to find that it stretches out like liquid and engulfs him. This metallic, mercurial liquid is reminiscent of its first use as a special effects device in the *Terminator II.* He nearly dies when the liquid pores into his mouth and down his throat. When Neo awakens, he finds himself attached to wires and encased in goo. In this scene, the means of transport from illusion to reality is a flexible metallic substance. Neo is shocked to find that the mirror is not behaving as a mirror should. Instead of presenting him with the stable image of his own reflection, it washed over and in, inside of him. Neo's rebirth into reality is traumatic, messy, and painful.

The central theme in this film is that the interface is used as a means of transportation and as such it is also a means of transformation. The interface allows the mind to travel while the body slumbers. Neo's physical encounter with the technology of the Matrix (the interface) is painful. Despite the clever ways in which our heroes wield the power of technology, the Matrix exists in an incommensurate relationship to the body. The film reflects the underlying logic of alchemical transformation. The metamorphosis of the mirror into liquid reveals that secret potential is hidden within material recalcitrance. This transgression really amounts to an artificial acceleration of time. In keeping with a theory of primary substance, glass is liquid slowed down by the portion of 'earth' that it contains. As we learned from Paracelsus, when one thing or substance changes into another thing or substance, and especially if that process is to appear 'realistic,' it must adhere to the basic law that within a thing that changes lurks an essence that does not change. Although such images are ubiquitous in contemporary examples of digital animation in film, it is particularly important in a film whose thematic and technological representations closely parallel one another. *The Matrix* suggests that reality amounts to the

uploaded, or transcendent mind, a fully abstracted and rarefied substance that alters our perception of material reality at the same time that it conjures an alchemical worldview, one that also believed in the artificial manipulation of matter.

The interface is the portal that mediates between the material and the ideal. Neo is, therefore, an object of transmutation in that body and mind, matter and essence are separated from one another only to be reconnected under more abstract conditions within a virtual space. However, an alchemical conjunction recombines Neo's refined, transformed, and resurrected body. The opposing realms of body and mind are now indistinct. In the Matrix, Neo can control material reality and physical laws with his mind. Therefore, those functions thought to be the exclusive province of each are transposed through an alchemical separation of essence and matter.

Another scene that warrants attention concerning the role of the body occurs in the collection of animated shorts, *The Animatrix,* whereby after the war between machines and humans, the victorious machines make their demands at a final United Nations Council. "Your flesh is a relic, a mere vessel. Hand over your flesh and a new world awaits you."[385] The attribute that distinguishes man from machine, the flesh, is rendered obsolete by the superiority of creatures that are not subject to decay and death. Like humans, however, the machines require fuel and the following scenes of the narrative provide us with a gruesome glimpse into their means of extracting energy from humans' "simple protein-based bodies." The scenes depicting humans being tortured and barely kept alive for experimental purposes is particularly shattering. Like so many dystopian science-fiction narratives, human flesh is set in stark contrast to the invulnerable properties of electricity and metal. The flesh is an inadequate container for the mind

[385] "The Animatrix," (Burbank, CA: Warner Home Video, 2003).

because it is subject to pain, decay, and death. It is a relic because it is inefficient and fragile. It is the very reason that humans lost the war.

Curiously, human flesh may be a liability in the film's narrative, but it symbolizes the Holy Grail of perfection for the digital animators, effects technicians, and software designers for the production of the world of *The Matrix*. In other words, the production of the film is motivated by the goal to seamlessly render the life-likeness of the human form. The irony is that, dystopic standoffs between machines and humans notwithstanding, the human flesh is the hardest thing to realistically recreate even with the benefit of smart digital machinery. Yet this is only one of many puzzling ironies elicited by an examination of the material and textual components of the film. Essentially, the disparate physical states of flesh and metal congeals at the epicenter of technological ambivalence. Recently, great strides have been made in the photorealistic digital representation of human form and face. *The Matrix* makers were among the first to innovate this technique. Computer graphics and virtual reality are technologies of transcending the body. The alchemists also sought to transcend the body. In the attempt, however, both realms find themselves more firmly encased within the flesh and its limitations than ever. What seems like a liability in interface design and in transmutation (excess matter or flesh) turns out to be inextricably wedded to the process. Attitudes toward the body and its relationship to the abstract mind are thus being re-constellated and reconstituted in terms that harken back to pre-industrial understandings of the body and the mind.

Some authors and journalists have made reference to the ironic juxtaposition of sexy and sleek with the monstrous and ugly. For a long time, cultural discussion of technological innovation has polarized around utopian and dystopian discourse. On the one hand, technologies (particular those that offer improvements in the realm of travel and communication) afford more

and better chances for society to fulfill its democratic dream. On the other hand, there is a threat that we will become enslaved to technology, depending on it so much that we lose something of our own humanity, our capacity to adapt to our environment and to preserve the noble ways of our elders.

These readings of scenes from *The Matrix* trilogy exemplify, on both a textual and formal (technological) level, the themes outlined in Chapter 2 on interface design. As shown in that chapter, interface design is largely guided by principles of embodiment and ease of access. Just as digital animation is driven by the goal of realism, interface design is driven by the goal of transparency in that it seeks a seamless, immediately accessible relationship with the end user. Both in the use of virtual technologies to create the film and the themes that revolve around using technologies to transcend the body, the *Matrix* films underscore the metaphysical issues that are central to contemporary musings on the cultural role of technology. One way to understand the historical and cultural origins of the interface is through an analogy with the goals that drive alchemical transmutation. In the following, I discuss the goals, process, and results of interface design in tandem with alchemical goals, processes, and realities.

One of the main goals of interface design is to achieve transcendence of the body and material reality. Similarly, alchemical transmutation was not just concerned with making gold (discovering the philosophers stone which I have compared with the goal of realism in digital animation). The alchemist was equally interested in transcending the limitations of his or her own body in order to become a so-called "golden person." The manipulation of material reality and the artificial simulation of natural laws amounted to obtaining a kind of immortality on earth. This is precisely the type of transformation that occurs in Neo throughout *The Matrix* trilogy. However, as I have shown, this is not merely a thematic component of these films rather it

permeates the technological architecture of interface design itself. As seen in Chapter 2, designers frequently discuss the mechanics of the interface in terms of a magical transformation or transcendence of the limitations of materiality and the body.

Just as special effects in the graphics industry has attempted to harness the power of digital code to transcend the clunky dead weight of stop-motion modeling, puppetry, latex, and plastic, so too, interface design seeks to dissolve the unwieldy relationship between the body of the user and the virtual tools at his or her disposal. Digital design and alchemical transmutation are crafts that take for granted the simultaneity or co-extension of the mind and body of the practitioner. Manovich underscores this goal for virtual reality by claiming that early work in virtual "capabilities did not distinguish between internal mental function, events, and processes and externally presented images."[386] This is similar to the claims made of alchemy. In both digital and alchemical, the material medium for transformation (the interface or philosopher's stone) and the practitioner's body are conceived of as obstacles to achieving the end goal—transcendence. It is an obstacle because the interface is incommensurate with the body of the practitioner. The GUI functions as a portal to enter a virtual world and conduct transmutations in that world. It is a catalyst because it is a mechanism for intuitively transcending the body for the purpose of accomplishing metamorphosis. The interface functions much like the mediating mechanism of the philosopher's stone for the alchemist because it is a device for catalyzing artificial transformations in real substances. The philosopher's stone is both a real thing and pure spirit. Likewise, the interface is a thing, and a pure abstraction. It is a conventionalized set of symbols designed to allow the human operator to enter a non-human realm, i.e., sacred and/or virtual space. The philosopher's stone and the interface are imbued with certain "magical" properties due to this crisscrossing of space that allows for artificial copies and simulations of

[386] Manovich, *The Language of New Media*, p. 56

nature. The goal is not necessarily to obtain gold/realism itself, but to obtain a precious medium for catalyzing infinite transformations that bring the practitioners closer to that goal. The reality, however, is that these design goals often fail to materialize, and users complain that interfaces are still difficult to use, let alone master. Animators and alchemists try to bypass the problem of mediation that transforms one reality into another by seeking an unmediated and direct relationship to that reality. Yet the attempt to achieve a natural relationship between the user and the interface, one that resembles interaction with objects in the real world, is also a receding goal. As with photorealism, the goal may be impossible, but it is nonetheless the perennial longing that drives the whole process.

Both realms are fraught with obstacles and failures that prevent the ultimate attainment of these goals, and instead, result in endlessly receding practices that create more problems as soon as the old ones are solved. Alchemists find that the substances they are trying to transform into a philosophers stone, keeps generating a residue. Natural organic processes that are being copied, however, do not produce waste that cannot be easily absorbed back into the eco-system. The interface, a mediating tool that positions itself between mind and matter, intuition and ergonomics, also produces waste. On a practical level, interface design generates an even more confusing array of options, presented through continually unfolding lists of menus and icons. On another level, the residual components to poor interface design are such physical ills as carpal tunnel syndrome, strained eyes and backs, due to the clunky, unnatural, and highly conventionalized relationship between body and machine. Designers, therefore, propose augmented reality environments rather than traditional computer screens in an effort to render the relationship more natural. For instance, the historical development of the mouse and the dataglove are meant to release the user from the keyboard. Yet this process of transcending the

machinery is never really 'complete' because, as in digital realism, one process creates new problems that lead to new solutions ad infinitum.

The benefits of using alchemy as a cultural prototype for contemporary digital animation that set precedents for understanding the relationship between representation and embodiment is that the alchemical worldview saw mind and matter as co-extensive and transformed this philosophical insight into cultural practices. The element of craft is very important in linking the alchemists of old to the digital alchemists of today since both set out to bend physical and temporal laws. The themes foregrounded in *The Matrix*—mind/body, reality/simulation—are thus reflected in the concerns and practices of the film's production, and the ancient practices mastered by the alchemists. As Kenneth Rufo rightly identified, the technological function of the interface is to mediate between primary dualities of mind and matter, or the real and the symbolic.

As a contemporary cultural artifact, the *Matrix* films are special in that they simultaneously foreground two ontological registers—technological architecture and representation. These two realms are connected by the medium of the interface—the computer and filmic screen that translates abstract data into a form of representation recognizable to humans. What is especially important in the film, is that these two levels, form and content, play reflexively against one another. *The Matrix* is about transcendence and disembodiment on the thematic level, while on the structural level, it deploys the very technologies of digital interface hailed as controversial because of their reconfiguration of the status of the human body. In other words, at the level of meaning the film suggests that the technology must be abandoned if humans are to be truly free authentic agents (human beings are enslaved by technology). This is a familiar theme in dystopic narratives that offer an image of humans rendered obsolete by

machines that are mentally and functionally superior. On the other hand, the very apparatus that is responsible for the film's dazzling special effects, is itself a matrix!—i.e., a computer-human interface.

In short, I have shown that the goal of obtaining gold in alchemy and the goal of obtaining realism in computer graphics and interface design are similar at the material level. Each comprises a process whose goals recede further away, just as the end point seems to be drawing near. Both involve a basic struggle between the body or matter, and the mind or transcendent spirit because both seek to transcend the flesh or matter, while at the same time acknowledging the dependence on the body for that very transcendence. The sympathy and antimony between these dualities is an entrenched aspect of Western cultural, religious, political, and aesthetic history.

6.0 CONCLUSION
A SPARK OF RECOGNITION: REFLECTIONS AND PROVOCATIONS

Like John Durham Peters and Michael Taussig, whose wonderful books inspired this project, I have "somersaulted" over vast periods in time. In doing so, I have tried to demonstrate that the major critical insight of the postmodern age is that the temporal and disciplinary boundaries that divide us from our past are arbitrary, subjective, fictional, and convenient. Nevertheless, we relinquish this hold on the partitions of time only very slowly and hesitantly in our work and scholarship. The vast majority of scholars of media, technology, and culture, therefore, (although with a variety of different results) consistently theorize the digital age as a revolutionary break with the past. To different degrees, these scholars, rightfully, are interested in how new media technology constitutes a unique period in time. I do not doubt that we live in a unique epoch. Fortunately, Benjamin's theory of history supports both historical continuity and historical rupture simultaneously. But I have found that a great deal more justification is required to foster a theory of continuity, especially between modern and non-modern periods, than to examine the ways in which our contemporary moment differs from the past. I have found a cache of cultural attitudes toward materiality, technology, and transformation in the processes and artifacts of a group scholars and scientists, occupying a vast span of history, that significantly add to our contemporary theories of digital technology.

The benefit of using an alchemical tradition as a cultural prototype for contemporary digital animation is that its similar view of the co-extension of mind and matter helps us to unravel the metaphysical problems associated with theorizing the role of new media technology

in our increasingly digitized culture. For both alchemy and digital technology, the artificial manipulation of material reality promises a kind of deliverance from the constraints imposed upon us by material and natural laws. The insights garnered from alchemy, however, show that the great benefit of a system of representation based on process also amounts to a liability. The definition of the simulacra as a perfect copy that collapses the distinction between the real and the false, is tempered by a form of representation that attempts to copy processes and not products—specifically natural laws. The metaphysics of artificiality requires this absolute distinction yet interdependence between the real and the fake because, as Benjamin shows, neither would have any meaning as a category if the other did not ruthlessly maintain its diametrical relation to the other. The benefit is that the artificial mimicry of authentic natural processes, promises to vivify inert objects and bring about 'lifelikeness.' It almost succeeds as we witness digital animating techniques render with precise accuracy such things as surface imperfections. Nevertheless, it ultimately fails at the 'perfect copy' which is its goal—a goal that recedes ever further onto the horizon, because, unlike natural processes, artificial ones generate waste that cannot be easily recycled. Cultural artifacts resonate with the remnants of the fears and hopes of the past which was once the present. These wishes and hopes are thus reflected, like a mirror, in our contemporary moment, and at best, awaken the individual to the revelation of what has always been.

In the Introduction to this dissertation, I situated this project within a body of new media scholarship in terms of its historical and cultural approaches to digital technology. In Chapters 1–3, I examined the professional standards, practices, and goals of digital design and alchemical crafts, showing that these goals are shaped by material and contextual constraints stemming from the longing to transcend the body and the material world. Chapter 4 gathered these separate

historical periods together to demonstrate the continuity between the techniques of their craft and the desires that animate their goals. Now, I conclude this dissertation by placing my theory of digital alchemy within a historical trajectory of thinking about the nature of materiality and artificiality.

It is an enduring aspect of human cultural history that we require technological enhancements to access, copy, or transform organic reality. In numerous contexts, from the professional, critical, popular, and academic, the desire for direct access to reality is a pivotal issue around which much ambiguity concerning technologies of mediation revolves. Essentially, one of the issues at stake is whether technology is a means to access nature or to separate us from it. It is clear that practitioners of digital and virtual design set out to simulate the minutia of natural phenomena but end up creating an even wider gap between their representations and the organic world, produced and sustained through these artificial mechanisms.

To assert that digital technology is revolutionary and that it moves cultural history beyond mediation is also to assert the uniqueness of our present technological moment. However, the desire for immediacy itself has a history that is not easily overcome. The legacy of alchemical transformation shows that this problem has a rich cultural history and has endured for a long time. The metaphysical language of alchemy helps us understand the pervasive dilemma of transcendence in new media theory since the transparent interface is yet one more manifestation of the desire to deny the mediated character of digital technology altogether, in the hopes of bypassing the body and the conditions of material existence. This desire to transcend materiality, has been a defining feature of Western visual (and for that matter verbal) representation. At each historical stage, one thing remains consistent—we use mediation machinery to try and transcend that technology and access the real directly. The process is

ultimately more interesting than the goal since the goal of accessing reality, due to the artificiality of mediation tools, is always just out of reach.

Almost every historical epoch has figured cultural attitudes toward technology in various forms of representation. In drama, short stories, novels, photography, painting, and film, cultural fears and hopes concerning science and technology are reflected, inflected, and deflected. The Matrix films are yet one more installment in a long tradition of thinking about the relationship between the human body and technological augmentations of the body. The common thread linking the many different forms of science fiction narratives is the culturally ambivalent relationship between humans and machines. This dissertation has added a third dimension to that relationship, one that mediates between flesh and metal—the interface. However, the interface as a cultural artifact prefigures the interface as technology. In the cultural imaginary, the interface functions as a portal or mechanism to shuttle the body, mind, or both, of a character between alternate realities. This theme was circulating in the cultural imagination long before interfaces were invented. For instance, the theme of traveling between alternate realities is showcased in such classic texts as *Alice and Wonderland* and *The Wizard of Oz*.

Part of addressing the historicity of such large and illusive themes as transcendence and realism is to explore the cultural sites that are concerned with these issues, not merely in the abstract but in terms of actual practices. I have explained the ways that scientific dead-ends (a belief in the elements, astrology, and alchemy) have had a lasting, if subversive, impact on cultural attitudes toward material transformation. This ancient paradigm is constantly evoked in the new media technology literature because the kinds of problems that the artifacts of digital processes present cannot be approached with the old constructivist, interpretive, symbolic, or ideological paradigms alone.

Alchemical transmutation is an important historical moment in the development of cultural conceptions regarding artificial extensions of the human body. Both are means of unlocking the hidden potential or life force that lies dormant and invisible in material reality. In the words of one technology scholar, "By adopting state-of-the-art technologies and applying mathematical and scientific models (cybernetics, information theory, structuralism), artist-engineers attempted to reveal the creative potential lying hidden in these technologies."[387] Ben Laposky, computer graphics pioneer of the oscilloscope, states that computer technologies afford "visual manifestations of some of the basic invisible aspects of nature, such as the movements of electrons and energy fields."[388] Similarly, the alchemist-artist-scientist-engineer sought ways to transform the basic chemicals and metals, thought to be the foundation of life, to recreate organic processes by unlocking the essence of life lying dormant within them.

As I have tried to show in foregoing chapters, a theory of material transformation must be applied to the two levels of digital artifacts—technological architecture and text. In the process, we find that the capacity to endow inanimate objects with life is a constant source of puzzlement, pleasure, and fear. The best contemporary example of this is the shiny, magical commodity delivered to us as a sacred object, wrapped in plastic, seemingly appearing out of the ether and never touched by human hands. Is it complicit with tawdry mass culture or is it the golden object worthy of analysis and unlocking the secrets of history and the culture of human desire? The dream of a perfect society is fostered by the promise that technologies of cultural production will be integral to achieving that end. Whether or not this state can be achieved on earth, is a beloved topic of many literary and filmic treatments. Both digital and alchemical transmutation offer the promise of bodily transcendence on earth by purifying the body of its sullied portion of flesh—

[387] Erkki Huhtamo, "Time Traveling in the Gallery: An Archaeological Approach to Media Art," in *Immersed in Technology: Art and Virtual Environments* (Cambridge: The MIT Press, 1996).
[388] Laposky, Ben. [as quoted by], Ibid., 238.

the portion that is subject to death and decay. The dystopian counterpart to this yearning, as demonstrated in countless science fiction films, including *The Matrix Trilogy,* is the possibility that the artificial might exceed its master in strength, intelligence, and endurance since the purification brought about by technology renders human flesh obsolete.

What is the status of the real when the real can be manipulated and copied with such (and for some, unsettling) precision? The mortification of the flesh and its surrender for the sake of higher goals, turns out not to be the exclusive province of theology. Rather, religion got hold of a more pervasive cultural problematic that persists across time and cultures. To reconstellate the problem of embodiment as a long-term cultural issue that predates Christianity is to foreground contemporary ruminations over the status of experience and reality when that reality is now rendered virtual. Virtual reality forces us to reexamine our historical categorizations of body and mind and to witness just how fragile this separation really is.

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