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An image is projected on a screen: it is abstract and intricately, impossibly detailed; luminous and smooth, its filigreed structures recede toward computer-graphic horizons. On another screen, a moving image is projected; a dense grove of synthetic foliage conceals a group of what appear to be insects. The viewer's image, mirrored within this artificial environment, causes the insects to recoil and retreat. On yet another screen, an animation shows an intricate, geometric flower unfurling, extending snaky tendrils into a digital void; it spins and writhes, filling the frame. In a gallery space a group of intricate white sculptures stand on a table, forms made up of masses of tiny cubes, three-dimensional pixels. On a nearby computer monitor, similar forms appear in an ever-changing series. An artists' statement describes how these forms arise as a cubic volume



differentiates itself, splitting like a living cell but at ever finer scales. Elsewhere a bicycle-wheeled robot rolls around a room in a nervous interactive dance with the people gathered there: it advances and retreats, spindly body rocking back and forth. Another room is filled with loud, skeletal machines that shriek and flail, seemingly attacking each other, menacing passersby with blinding lights and horrendous noises. In yet another, quieter space, three arms made from grape vines and wire twist and pivot from the ceiling, "singing" to each other in telephone touch-tones.

These are strange objects, embodying a series of contradictions and ambiguities. They are technological objects, this much is clear; made from the glowing points of light on computer screens, or from metal, motors, and electronics. Yet unlike the technological objects we routinely encounter, they are unpredictable and apparently

autonomous; something in their movement, their reactions, their structure, reminds us — is clearly intended to remind us — of living things. They are art objects; we find them in galleries, at symposia and conferences, among other art objects made of computer code and electronics. Yet some of them are hardly objects at all; they refuse to sit still and be observed, but hide from us, play with us, or invite us into their own virtual worlds. Clearly, these things are made — they are the works of artists or others working artfully — but the signs of the will of a creator are sometimes less palpable in these objects than the manifestation of a "will" of their own. And while these works can be found in galleries and festivals, under the banner of art, they might also appear with their creators at conferences of another stripe, alongside elaborate computer simulations of cellular biology and crawling, multilegged robots, the technological objects of the science of artificial life.

Artificial life, or a-life, is a young, interdisciplinary scientific field concerned with the creation and study of artificial systems that mimic or manifest the properties of living systems. It is a strange object in itself; its Promethean project to create new forms of life arouses scepticism, fascination, and alarm in equal measures. Having turned (in part) away from the task of analyzing nature and toward its synthesis, a-life seems unlike a science in the conventional sense. However, the objects just described are, if anything, stranger still. While they apply the techniques and ideas of artificial life in a variety of ways, they present themselves as art objects rather than as scientific artifacts. They are manifestations of a kind of transdisciplinary dissemination of artificial life, the results of its recent propagation through cyberculture and popular science writing. They arise where artificial life meets contemporary practice in the new media arts.

This meeting point provides the location for this project, and these strange objects, their makers, and the thought and writing around them are the objects of its attention. This complex is interesting and significant for a number of reasons. Most immediately, the artwork itself is striking. It evolves, responds, mutates, and forms complex, supple systems and cryptic alien artifacts. It offers engaging experiences, interactions with complex looking-glass worlds and embodied agencies, encounters with weird aesthetic objects. Beyond the immediate experience, these works tend to become more difficult, though no less interesting. The elegance of the engineering — the beguiling way these systems operate — counterpoints a sense of suspicion at the lines of metaphor and association they draw. How is this lifelike exactly? At times, this practice entails an expansive, godlike creative sweep, bringing whole worlds into being, populating them with virtual creatures. Ingenious, certainly, but is this also an extreme form of artistic hubris? At the same time, conventions of creative agency are stretched to breaking point: much of the work is made in such a way that it makes itself — it is somehow autonomous. Is this an abdication of creative will or its ultimate fulfillment?

More generally, this work is important in that the mapping around which it pivots, between living things and technological systems, is provocative, problematic, and highly current. Western culture is in the midst of an explosive development in the technologies of life and the living: the modeling, simulation, decomposition, engineering, and manipulation of biological life. Contemporary culture is slowly coming to grips with radical changes in its notions of life as medical and biological technologies reveal living matter as increasingly plastic and susceptible to engineering. Stem cells — unspecialized protocells, a kind of basic living material — are isolated and cultured. Reproduction, conventionally a unique and definitive capacity of the living organism, is ever more readily engineered and

decomposed. Large mammals are cloned, and some strive to clone human beings, raising ethical rather than technological questions. Proprietary life forms, genetically manipulated species, are grown as food crops. Distinctions between natural and artificial, born and made, become unsupportable. Technoscience seems to have an ever-increasing command of living matter, and in an era of global capital, life is reshaped according to logics that are principally commercial.

However, at the same time, life itself continues to escape and evade technological control; it remains active, retains an agency. In fact, technological interventions seem to create unforeseen opportunities for living things. During the late 1990s, outbreaks of bovine Creutzfeldt-Jakob disease ("mad cow disease") demonstrated how even the most primitive organism can work through, and ultimately against, a technological network. The gruesome efficiency of industrial agriculture forms a feedback cycle; the protein-folding prion, barely even alive, crosses species barriers and infects the human consumers at the top of the food chain; entire industry sectors close down. Elsewhere, genetically modified crops escape their fenced-off testing grounds to compete and possibly interbreed with the surrounding biota. Antibiotic-resistant bacteria thrive in hospital wards.

The tangled counterpoints of biology and technology are ubiquitous. Computer viruses proliferate, with an impact as real as the biological variety — or in a technocentric business culture, more so. The industrial networks that host the technologization of life are simultaneously engaged in the decimation of biodiversity and the destruction of habitat. In April 2002 a Japanese institute launched the Earth Simulator, currently the most powerful supercomputer in existence; it runs massively detailed climatic and seismic simulations. If successful, it will improve weather prediction and warn of impending earthquakes; in the words of one of the scientists involved, the project aims to "keep a good relationship between nature and mankind, a symbiotic relationship. . . ."[1] A large-scale digital simu-

lation seems to act here as a benign intermediary; yet at the same time the accelerated currents of digital media tend to pull us away from the difficult, polluted, outside space of the physical world and toward the clean, controllable "inside" of mediated experience and synthetic immersion. Life and technology, biology and information, hang in a tense articulation.

Against this background, a cultural practice that is engaged with both technological culture and biological science is in a particularly interesting position. New media art, the primary context for this practice, is already deeply enmeshed in a wider technoculture; its standard practice is to take up the products of the technology industries — focused recently on personal and networked computing — and apply them to its own diverse ends, in a cultural domain. It draws on these technical resources but also characteristically reflects on and critiques them. New media art self-consciously reworks technology into culture, and rereads technology as culture. What's more, it does so in a concrete, applied way; it manipulates the technology itself, with a nonindustrial latitude that admits misapplication and adaptation, rewiring and hacking, pseudofunctionality and accident. New media art also fractures that technocultural material into millions of heterogeneous interests and agendas, specific investigations, aesthetics, approaches, and projects.

When this practice begins adopting and adapting the technoscience of artificial life, it comes to grips with a troublesome constellation. A-life crystallizes the conjunction of biological life and technology into a handful of bold claims and images. The computer in this context seems to contain not only organisms but whole living systems in detailed articulation. Evolution, an idea that has become the most powerful organizing narrative of contemporary culture, appears to unfold on a screen. A-life proposes not a slavish imitation of this or that living thing but, at its strongest, an abstract distillation of aliveness, life itself, reembodied in voltage and silicon.

In appropriating (and altering) artificial life, the artists considered in this book are engaged in a crucial task: that of working through the implications of its concepts and techniques, testing their potential, deforming and transforming them. These operations are only partly technical; they are primarily and most importantly cultural. New media art provides a venue for the transformation and translation of the technical and conceptual artifacts of artificial life into cultural objects — conglomerates of rhetoric, metaphor, and aesthetics. Such translations are important in general because of the terms they articulate; at a time of rapid and dramatic technological change, the process of assimilating, debating, contesting, and reflecting on that change within cultural domains is crucial. The interface of artificial life and cultural practice is particularly significant for all these reasons; it opens a space for creative experimentation and debate around the increasing technologization of living matter as well as broader issues of life and autonomy, agency and evolution, genetics, code and matter. This work explores a practice in which we are all increasingly required to participate: the art of technologized life.

## Artificial Life

Artificial life is a field of scientific research devoted to the simulation and synthesis of living things. It was founded in 1987 with a workshop at the Los Alamos National Laboratory, New Mexico. In subsequent years, interest in the field has grown: the artificial life workshops have become an ongoing international series, and the field has spawned dozens of other conferences; 1993 saw the publication of a journal dedicated to its work. The handful of scientists involved in the initial workshop has grown into a small international community.

Of course, efforts toward the simulation or synthesis of life are far older than this field. What distinguishes a-life from earlier work, and what unifies it currently, is a specific approach to this task. A-life be-

gins with a notion of life that is wholly materialistic, involving no soul, vital force, or essence. In the words of the convenor of the first artificial life workshop, Christopher Langton, "Living organisms are nothing more than complex biochemical machines."[2] Langton contends that rather than being any special substance or force, life is "a property of the organization of matter."[3] Further, this organization is not simply a complex structure but a dynamic structure, a system active in time: for a-life, life is most importantly manifest in behavior. If, then, the "universal features" of life are in its abstract dynamic processes rather than inherent to a biological medium, we can consider the creation of such structures in another, artificial medium. Artificial life sets about creating such dynamic structures, almost always involving the most flexible, dynamic, and tightly controllable artificial medium at its disposal, computation.

It is this sense of living things as complex dynamic systems that informs the methodologies of artificial life. A-life's focus on the synthesis of such systems leads it to adopt the "bottom-up" approach that is one of the field's tenets. Influenced by theories of complex systems, a-life regards the complex dynamics of living things across all scales as phenomena that arise from the interaction of multitudes of smaller elements. Langton asserts that "natural life emerges out of the organized interactions of a great number of nonliving molecules, with no global controller responsible for the behavior of every part." Similarly,

> Artificial life starts at the bottom, viewing an organism as a large population of simple machines, and works upwards synthetically from there — constructing large aggregates of simple, rule-governed objects which interact with one another nonlinearly in the support of life-like, global dynamics.[4]

The process, known as emergence, by which these simple components interact to produce complex, lifelike results is another central

concept in artificial life. Just as artificial life proposes that the complex behaviors of a living thing emerge from its nonliving parts, it seeks to recreate this process in artificial systems, so that an ensemble of simple computational parts interacts to spontaneously produce lifelike dynamic structures.

A useful way to briefly provide a sense of a-life's approach and its particular innovations is to examine the way it distinguishes itself from artificial intelligence (AI). It does so frequently, and tends to present itself as succeeding in its aims where AI has failed. Langton explains that in focusing on intelligence — the underlying mechanisms of which were (and are) poorly understood — AI was left without a model to follow and resorted to "serial computer programming," a methodology that "bore no demonstrable relationship to the method by which intelligence is generated in natural systems." Conventional AI strove without much success to make computer programs that could think; its approach was centralized, or "top-down," and focused on cognition. A-life, in contrast, deals with behavior that emerges from the bottom up. Langton describes a-life as remaining "true to natural life," following the "key insight" that "nature is fundamentally parallel" — that is, natural systems tend to be complex aggregates of parts, each of which has its own "behavioral repertoire"; behavior arises out of the parallel operation of these parts.

A-life has developed and adopted a repertoire of formal structures and techniques that apply this philosophy. While this repertoire is not fixed or static, there are a handful of key techniques, which bear introduction here.

*Genetic algorithms,* a central technique, roughly simulate biological genetics in digital computation. A genetic algorithm involves a "genotype," which is a string of code specifying a "phenotype." The phenotype can be any digital artifact: an artificial organism, a three-

dimensional form, or a piece of software. By simulating the genetic variations caused by sexual reproduction and mutation, a genetic algorithm alters the genotype and the phenotype; and since this process is computational rather than biological, breeding is rapid and prolific. Wide ranges of possible phenotypes can be generated, which are often automatically evaluated for their "fitness," based on some formally specified criteria. In functional applications, an accelerated process of artificial evolution is applied to find a solution to a complex problem by searching within a large range of possible outcomes.

*Agent-based systems* often also apply artificial genetics. These systems model individuals interacting in an artificial world; their behaviors may be as basic as breeding and eating or as sophisticated as "communicating" or cooperating. Population dynamics may emerge, such as fluctuating predator/prey balances; with artificial genetics, agents' attributes may evolve, so that phenomena such as speciation, interbreeding, symbiosis, and coevolution become possible. Some simple agent-based systems involve no genetics yet exhibit a-life's characteristic bottom-up dynamics: in *flocks* agents follow simple rules for moving through space; each individual seeks to maintain a certain distance from the others while moving forward.[5] The result is the spontaneous formation of a flock of agents, with a supple coherence that resembles that of real-life flocks or shoals.

This architecture of decentralized control has also been applied in robotics: in *bottom-up robotics* multiple sensorimotor processes operate in parallel, in the absence of a controlling "brain", or an internal representation of the sensed world. As the work of Rodney Brooks and the MIT Robot Lab has shown, this architecture can generate simple, computationally efficient robots with surprisingly robust behaviors.[6]

Finally, *cellular automata* manifest this local-global transition in a purely formal domain. In these systems, an array of logical units or cells is computed with a set of simple rules for how each cell's future

state is affected by the current states of its neighbors. In the best-known cellular automaton, the Game of Life, a two-dimensional array of one-bit, on/off cells and a handful of simple transition rules give rise to what seems to be a clockwork nanobestiary: cell formations blossom and disintegrate; oscillating, mobile formations crawl across the array.[7] This striking emergence of complexity from simplicity, and lifelike dynamics from formal rules, is frequently invoked in arguments for the merits of the a-life approach.

## A-Life Art

Shortly after artificial life's self-declared inception in 1987, artists began to apply its techniques. Its earliest adopters were artists with interdisciplinary interests, followers of the biological and computational sciences who had the technical and conceptual means to begin experimenting with artificial life. William Latham and Karl Sims were prominent among these; their work was shown in major cultural institutions and on the new media festival circuit in the early 1990s. It demonstrated the viability and some of the potential of the conjunction of a-life and art making, and sparked the interest of other artists working in digital media. Since then increasing numbers of artists have taken up a-life concepts and techniques. While in terms of contemporary culture, or even contemporary art practice, a-life art remains a "fringe" activity, it has come to be recognized as an active area within new media practice. Publications such as *Leonardo* and festivals including Ars Electronica have devoted space to a-life art; in 1999 an annual competition for a-life art was inaugurated with *Life 2.0*.[8]

In a process mirroring the expansion and diversification of artificial life science, a-life art has come to encompass work in a wide range of forms, reflecting diverse intentions and perspectives. The early works in the field focused on a single key process — artificial evolu-

tion — and its application in generating aesthetic objects. In the following decade, artists began to draw on other elements and forms: ecosystem simulations, cellular automata, and behavioral robotics. These techniques are applied across the gamut of "new media" forms: digital image, animation, interactive installation and CD-ROM, on- and off-line virtual environments, and static, robotic and biological-robotic sculpture. Less obvious, though perhaps more important, is a corresponding diversity of conceptual approaches. Some artists endorse and play out a-life's aims for the synthesis of living systems; they reflect some of the progressive, futurist tendencies of a-life and the cultural discourses it has inspired. Others approach a-life critically, questioning the assumptions that underpin its techniques as they turn those techniques to creative ends. Still others draw on the technical resources of a-life only to alter them, reconfigure and reengineer them to serve particular aesthetic and conceptual concerns.

Contemporary new media artists use a-life in a variety of contexts, to a variety of ends: some works pursue an absolute, self-sufficient autonomy; others use an appearance of autonomy to provoke empathy or raise questions about human agency. Many of the artists using a-life strive for a supple, engaging form of interactivity and a work that draws the audience into an active relationship; others present aesthetic artifacts that arise through their own intense engagement with a-life processes. Some of the works considered in this book set about creating whole artificial worlds, and others seek out a complex, dynamic relationship with the physical "outside" world. In many works, the familiar appearances and behaviors of nature are imported and reproduced; the natural world is redrawn within computational space. In others, the process of rendering biology as computation comes under question; in still others, the familiar image of nature gives way to something else: a raw, blank sense of potential, of the unknown and of what could be.

Defining or delimiting a-life art is problematic, of course, though it is necessary for a review such as this. We can situate the field within a wider area of art practice that engages and applies technoscience in its form, content, and technique; Stephen Wilson has named this area "information arts" and made a comprehensive survey of it.[9] There is a range of work here that approaches a-life art in various ways, with related concerns, techniques, and approaches. Artists are working with biotechnology, another science of technologized life, though one that operates in the "wetware" of living tissue. Many other artists draw on artificial intelligence, which while it shares some of a-life's interests in autonomous agency, emphasizes mind and thought over behavior and life. A host of other tech-art forms touch on artificial life: work with robotics, avatars, or artificial agencies; generative processes or simulated worlds; and work addressing that central articulation of the natural and the technological. This work is very often concerned with a notion of artificial life in the broadest sense. Some of it may even resemble or seem to manifest artificial life forms. However, in this book, in the interest of clarity and focus, a-life art is defined quite strictly as work that specifically and deliberately takes up the techniques and processes of a-life science.

## Precursors to A-Life Art

This definition gives the survey a very specific historical compass and a year zero, 1987, linked to the self-declared inception of artificial life. Yet in terms of developing an understanding of the field, it is essential to take a wider and longer view. As Lev Manovich has shown, the new media are not entirely new but have been anticipated and prefigured by old media practices and forms.[10] Such media prehistories enrich our knowledge of contemporary forms and guard against the technofuturistic rush that often characterizes new media culture. Similarly, in the interest of grounding a consideration of contemporary practice, it is useful to consider some precursors to a-life art practice. Yet how can we trace a-life art prior to a-life it-

self? Simply by suspending that definition momentarily and considering parallels in practice and theory. In contemporary work, artists apply and manipulate a-life's formal techniques for modeling (and perhaps instantiating) living systems. Broadly, art here seeks to mimic and apply the dynamic formal structures of life; and this book looks back to work that predates both a-life and a-life art.

The formal analogy that likens a work of art to a living organism is ancient, traceable to Plato and Aristotle, who use the body as a model of organization and coherence in discussions of rhetoric and drama.[11] That analogy reappears in the work of the German romantic poet and scholar Johann Wolfgang von Goethe around the turn of the nineteenth century. In fact Goethe's philosophy of nature parallels that of a-life in emphasizing an appreciation of the dynamic living whole over the constituent parts while also proposing a common underlying formal structure. This is exemplified in Goethe's notion of the *Urpflanze,* or "ur-plant," the archetype or template that underpins all real plant forms. Rather than a fixed template or Platonic ideal, the *Urpflanze* was, as one contemporary commentator remarks, "a vision of a dynamic pattern."[12] Goethe regarded the study of nature — based on an "intuitive awareness" of the organic whole — as a communion with the divine and the ultimate goal of art: "The highest demand made on an artist is this: that he be true to nature, that he study her, imitate her, and produce something that resembles her phenomena."[13] This resemblance is more than an image, however; it is procedural. In art "we can in the end rival nature only when we have learned, at least in part, her method of procedure in the creation of her works."

These ideas are echoed by Goethe's contemporaries and in a lineage of major nineteenth-century figures. Around 1800, August Wilhelm von Schlegel writes that art "must form living works, which are first set in motion, not by an outside mechanism, like a pendulum, but by an indwelling power."[14] Later, Samuel Taylor Coleridge

developed this notion in his critical writing on Shakespeare; for Coleridge, the true work of art is organic, and organic form, unlike the arbitrary imposition of "mechanical" form, "is innate; it shapes as it develops itself from within."[15] This is the idealist and Romantic core of a line of organicist thinking that manifests itself across the arts, in literary criticism, architecture, and musical analysis. In the visual arts these ideas are taken up in the European and Russian avant-gardes during the early decades of the twentieth century.

It is clear that a-life art is engaged, in a very general way, with the underlying forms of living things; however, it is also engaged in the translation of those dynamic forms into technological media, into structures of code and engineering, into explicit and formal rules and processes. The clearest predecessors for a-life art practice, then, are those that combine these organic ideals with a tendency towards rigor and systematisation, where creative organisms arise not through the transfer of an ineffable vital essence but from the interactions of formal elements in a medium deliberately abstracted from nature.

The work of Paul Klee provides a rich example of exactly this combination of organic idealism with formalist thought. Klee's work expresses a Goethean sense of nature but manifests it in refined, considered abstraction. Once again, Klee begins with the study of nature and an understanding that moves from surface to dynamic formal structure. The artist's intuition "can transform outward impression into functional penetration. . . . Anatomy becomes physiology."[16] Here, too, this intimate, structural understanding enables the artist to "form free abstract structures which surpass schematic intention and achieve a new naturalness, the naturalness of the work." Examples of this process can be found in Klee's notebooks. In one 1923 lecture, Klee makes a graphic analysis of plant forms that abstracts them into general principles and "forces"; the leaf stem is an energetic vector that exhausts itself as it branches, and at its endpoint is contour, the outline of the leaf.[17] Beginning in the ob-

servation of nature, this becomes a lesson in the rules of an abstract, graphic cosmos, and in the relation of line to contour and plane. Klee set a creative exercise demonstrating the final, synthetic, or creative stage of his methodology: it was entitled "Imaginary leaves on the basis of the foregoing insight into basic rules."[18] The notebooks show Klee's own example: an artificial leaf made up of stem vectors and outline contours. While here inner dynamics crystallize into form, Klee cautions that "form is the end, death. Form-giving is movement, action. Form-giving is life."[19] The organic artwork must ultimately be alive: "Our work is given form in order that it may function, in order that it may be a functioning organism."[20]

Some of Klee's contemporaries in the Russian avant-garde pursued a similar vision of the organic artwork, though with more emphasis on the role of technology. In particular, Kasimir Malevich, founder of Suprematism, produced an expansive utopian discourse of the artwork as an autonomous organic machine. While Suprematism is widely known for its pursuit of abstract purity, emblematized by Malevich's black square, Malevich, like Klee, writes of abstract form as an approach to nature's underlying dynamics and forces. In "On New Systems in Art" (1919), the artist, observing a natural landscape, "stands and exults in the flow of forces and their harmony."[21] When these dynamics are transferred into the artwork, we find not a copy or a tracing, but "pure" or "absolute" creation, and "a work of pure, living art."[22] In "Infinity . . ." (1919), Malevich writes that the "highest and purest artistic, creative structure . . . does not possess a single form of the existent. It consists of elements of nature and forms an island, appearing anew."[23] While their exact constitution remains vague, it is clear that these autonomous islands are at once organic and technological: Malevich imagines the Suprematist machine as a spacecraft, propelled "not by means of engines, . . . but through the smooth harnessing of form to natural processes, through some magnetic interrelations within a single form."[24] These forms are so refined, so perfect, that they cleave away from the mundane

Earth and become new, autonomous, artificial worlds: "All technical organisms are nothing but small satellites, a whole living world ready to fly away into space and take up a particular position. Indeed, every such satellite is in fact equipped with reason and prepared to live out its own personal life."

If the details of Malevich's vision are indistinct, it must be partly because of limitations in its raw material; it was based primarily in the mechanical paradigm that defined the technology of his time. With the rise of electronics some fifty years later came a form of technology that miniaturized and internalized the dynamics of the machine. It was this technological shift that made it possible for the Soviet Union, in 1957, to fulfill one element of Malevich's vision, sending a tiny ball of electronic circuitry into orbit around the Earth. Meanwhile, during the preceding decade, a new scientific field had been emerging in the United States, through the Macy conferences on "Circular Causal and Feedback Mechanisms in Biological and Social Systems." This was cybernetics, named by Norbert Wiener in 1948.[25] A predecessor of contemporary complex systems science, and thus artificial life, cybernetics set out to address problems across living and nonliving systems by considering both in terms of abstract causal dynamics, inputs and outputs, and feedback loops. Moreover, like a-life, cybernetics was taken up in cultural as well as scientific practices: during the 1950s, artists began to encounter and apply cybernetics. Throughout the 1960s, as interest in electronic and kinetic art forms grew, it was taken up more widely and also began to appear in critical and theoretical art discourse. This period throws up some striking precursors for contemporary a-life art.

Among the early adopters of cybernetic techniques was Hungarian-born artist Nicholas Schöffer, who gained wide attention during the 1950s and 1960s with his kinetic and cybernetic sculptures. His 1956 *CYSP I* was an articulated tower that responded to sound and

colored light by moving itself and its rotating metal vanes. Schöffer describes this work as "the first sculpture to have a human-like self-determined behavior."[26] The critic Jack Burnham writes that in *CYSP I* "ambiguous stimuli . . . produce the unpredictability of an organism."[27] For Schöffer, cybernetic techniques serve an aim of "nonredundancy," enabling art to keep pace with the perpetual novelties of the mass, electronic media. Moreover, Schöffer asserts, this is metacreation: "We are no longer creating a work, we are creating creation. . . . We are able to bring forth . . . results . . . which go beyond the intentions of their originators, and this in infinite number."

These ideas are echoed by James Seawright, a prominent American cyborg sculptor. He says of his works *Watcher* (1965–1966), *Searcher* (1966), and *Scanner* (1966), "My aim is not to 'program' them but to produce a kind of patterned personality. Just as a person you know very well can surprise you, so can these machines. That's the crux of what I want to happen."[28] All Seawright's works were cybernetic systems responding to environmental inputs; some, such as *Searcher* and *Scanner,* use feedback to dynamically modify their own programs. When grouped together, the works communicate among themselves: "The pieces interact and provide a continually varying pattern of independent and collective activity."

Artists in this cybernetic era also experimented with composite systems linking biological life with electronics in various ways. Anticipating Christa Sommerer and Laurent Mignonneau's *Interactive Plant Growing* (see chapter 3), Thomas Shannon and John Lifton experimented in the mid-1960s with living plants acting as electric pickups for robotic and sonic systems. A rare example of a warm-blooded composite is Nicholas Negroponte's *Seek* (1970), in which a robot arm transports and stacks two-inch cubes that form the "built environment" for a group of gerbils: the arm attempts to adaptively alter the structure to satisfy the desires of its rodent population.

With related work by Edward Ihnatowicz, Tsai Wen-Ying, and cybernetician Gordon Pask, and the animist kinetics of Robert Breer and Jean Tinguely, this period produced a strain of cyborg art that was very much concerned with the shared circuits within and between the living and the technological. A line of cyborg art theory also emerged during the late 1960s, and here again some striking premonitions of a-life art can be found. Writers including Jonathan Benthall and Gene Youngblood drew on cybernetics and cybernetic art, Benthall in his 1972 survey *Science and Technology in Art Today,* and Youngblood in *Expanded Cinema* (1970).[29] The most substantial contributor, however, was the American critic and theorist Jack Burnham. Burnham's *Beyond Modern Sculpture* (1968) builds cybernetic art into an expansive theory that centers on art's drive to imitate and ultimately reproduce life.[30]

Burnham begins at a point of artistic crisis: sculpture after World War II was apparently obliterating itself, abandoning traditional sculptural concerns for a dematerialized dynamism. This is a transition from object to system, Burnham argues, evident in forms such as kinetics, light art, cybernetic art, and environment art (13). With the rise of industrial capitalism, and the progress of science and technology, the modern environment is a sophisticated, interlocking artificial system, and this is reflected in art practice. This artificial system is, moreover, evolving; Burnham broadly invokes negentropy, or self-organization: it is "a common effect linking social, technical and biological evolution"; "each . . . moves towards a higher life form" (14). Art is inescapably involved: "sculpture . . . in a technological society must be regarded as a tiny microcosm of the entire . . . evolution." So, ultimately, if both art and technology are negentropic, then their common destiny is the creation of life. Burnham projects its arrival into the near future (our present): "The logical outcome of technology's influence on art before the end of the century should be a series of art forms that manifest true intelligence . . . with a capacity for reciprocal relationships with human

beings" (15). This drive is at the core of *Beyond Modern Sculpture:* it organizes Burnham's historical account of modern sculpture, and the cybernetic art of the 1950s and 1960s is held out as its most complete realization. Twin art-historical threads of organicism and vitalism — for Burnham, the quest to convey life's metaphysical essence — converge: "[V]italism is a transitional step in this process from inanimate object to system" (76), and "the meaning of organicism . . . has already begun to converge toward a single end result — the understanding of living matter through its creation" (51).

What we find in cybernetic art, in Burnham, and in Klee and Malevich, suggests that a-life art is only the most recent addition to a modern creative tradition that seeks to imitate not only the appearance of nature but its functional structures, and that applies (or imagines) technological means to do so. More striking, though, is the Modernist-organicist drive that runs through this history, where artificial life is the very destiny of art making. This rearranges the terms of the present investigation: instead of art following technoscience and importing its techniques, a-life itself is an artistic project, even *the* artistic project. Can we understand contemporary a-life art as a continuation of this drive? Does it finally fulfill Burnham's vision of a living, cyborg art form? As it happens, Burnham later renounced his predictions in the wake of his experience as curator of the ambitious but troubled 1970 tech-art exhibition *Software.* Writing in 1974, he denounces the "archetypal desires" of science to create artificial intelligence as "Faustian myths of the highest order."[31] Later, he writes of *Beyond Modern Sculpture* that it "erred gravely . . . in its tendency to anthropomorphize the goals of technology."[32] He dismisses the cybernetic art of the 1950s and 1960s as "little more than a trivial fiasco," and the results of AI research (circa 1980) as "pale imitations." In this dramatic about-face is another possible reading of a-life art: that it, too, is replaying Faustian myths as well as myths of technological, evolutionary, and artistic progression, and that it, too, will come to be seen as a "trivial fiasco."

However this practice may be judged and rejudged in the future, it is highly significant in the present, for all the reasons outlined. Moreover, in terms of the field's development, the present moment is one where a critical examination of a-life art practice has become both possible and worthwhile. Artists have been using artificial life for around a decade, a short span in art history though a longer one in the accelerated time scale of new media practice. For most of that time, new media art has adopted a-life techniques experimentally, in scattered, initial encounters. However, activity in the field has increased in recent years, and at the same time experimentation has given way (in part) to more self-conscious, strategic engagements with artificial life. The field has developed to a point where a wide analytical account can be valuable. While a number of writers have made isolated forays, a-life art as a whole has received limited critical attention. So, my aim here is to simply provide that critical account of the field — the work itself and the conceptual and discursive structures that surround it. This book makes no claim to be an exhaustive catalog of a-life art, but it does aim to represent the range of practice in the field. Further, while the field will continue to change, and the work presented here will inevitably date, the intention is to address the broader themes and drives that it manifests and so to give an account that will remain useful even as its details age.

Chapters 2–5 deal with the primary material, the work itself. Here, a-life art practice is presented through a simple typology based on four of its prominent techniques and tendencies. The first of these, Breeders, focuses on processes of artificial evolution — a group that includes the earliest works of a-life art. The second, Cybernatures, expands the scope of the simulation: many of these works are interactive computational systems that mimic the tangled interrelations of organic life; all address the tension between organic life, or "nature," and its technological double. Chapter 4, Hardware, considers work

that centers on a physical manifestation; as well as interactive robotic systems, this category includes biorobotic composites that involve a coupling between biological life forms and electromechanical systems. In chapter 5, Abstract Machines, the "life" in a-life recedes momentarily, in works in which the analogy implicit in these techniques is less important than their formal, generative properties.

Throughout these chapters the exposition of the work feeds directly into critical response and analysis. What is the work attempting? What does it achieve? What does it evoke or invoke? What does it exploit, critique, endorse, celebrate, or mourn? What are its implications? What does it suggest? This analysis also begins to abstract from individual instances, revealing commonalities and questions that bear on the field as a whole.

Chapter 6 pulls back to consider theoretical contexts for a-life art practice, which is not, of course, the only manifestation of artificial life in cultural thought. A-life has drawn the attention of some in fields such as cultural studies and anthropology, and their work makes some important contributions to an understanding of a-life art practice. Closer to that practice, there is a small cluster of writing addressing a-life art directly: artists and critics set out a range of aspirations, explanations, manifestos, proposals, and critiques. Reading these closely and analytically gives a sense of the variety of ways in which a-life art is being defined, justified, contextualized, and interrogated, and of the range of conceptual projects it contains.

Finally, Chapter 7 focuses on an elusive concept, emergence, which is at the core of both a-life science and a-life art practice. Emergence is the process by which complex systems seem to acquire new properties from one level of scale to another; centrally, how the complex interactions of inert matter at the microlevel give rise to life at the macrolevel. Emergence is central to a-life science's interests and its claims to be lifelike; a-life art, too, it will be argued, aspires

to a state of emergence and to the surprise, the excess, the "something more" which that entails. Chapter 7 sets out to explore the concept of emergence in some detail, investigating its provenance and history, the claims for its manifestations in a-life and a-life art, and the forces and structures that act to limit and condition its operation.

Emergence is such a beguiling idea that it might not be too pat to apply it reflexively here. In fact, that might be essential if we are to take a-life's connectionist underpinnings seriously and regard culture itself as a system characterized by an interwoven and processual causality, by complex dynamics that are continuous with those not only of living systems but of their material substrate. While a text such as this is frozen, a static block, its aspirations must extend outward into those ongoing cultural dynamics, especially in a case where the subject matter is itself in flux. That is, this book is not intended to "cover" a-life art, to summarize the field once and for all. On the contrary, it is a starting point, an element to be taken up in wider systems, as the field's complex future unfolds.