



This special issue of *Angelaki* is based upon the collaborative efforts of the Ontogenetics Process Group (OPG) – an interdisciplinary, multi-institutional, multi-national research group that began meeting in 2017 to explore new and innovative ways of thinking the problem of complexity in living, physical, and social systems outside the algorithmic models that have dominated paradigms of complexity to date.

This kind of interdisciplinary theoretical endeavor has a long history, of course, one that, in recent decades, has been largely occluded by the rise of Big Data, the neo-Darwinian paradigm and its obsession with the genome as an engineerable “book of life,” and the assumption that “hard” scientific knowledge is fundamentally quantitative in nature. It’s entirely possible, however, that that hegemony will, in the longer view, prove to be misguided or, at the very least, oversold (as even prominent proponents such as Craig Ventner have recently admitted).

For all the descriptive and predictive power that the complexity sciences offer (the ability to compute feedback systems, recursive

FOREWORD

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networks, emergent dynamics, etc.), they also presume that the living world in all of its modalities (biological, semiotic, economic, affective, social) can be reduced to finite schema of description that delimits in advance all possible outcomes. The mathematics of complexity function like a “grid of intelligibility” for physicists, biologists, economists, information scientists, sociologists, and now, many humanists; they permit the sciences of the living and nonliving to speak the same language. What distinguishes this group of researchers, and this special issue of *Angelaki* in particular, is the breadth of disciplinary and methodological frameworks brought to bear on the possibilities and limitations of this proposition. More than this, what is proposed

foreword

here are conceptual architectures for the living that are not only irreducible to physico-mathematical frames of reference but that are also as vital as the phenomena they wish to express. In short: life is more complex than complexity.

In a sense, this may not seem like an entirely new proposition for the theoretical humanities. A rich genealogy of continental thought engages with the contemporary biosciences through the vital materialist philosophy of Nietzsche, Bergson, Deleuze, Guattari, Simondon, Canguilhem, and others, and an astringent anti-reductionism is central to the work of figures as diverse as Derrida, Rorty, and Foucault. However, several features of the OPG's treatment of the biosciences and related scientific fields resist some of the unfortunate clichés that have come to characterize recent humanist engagements with science, particularly under the broad rubrics of "materialism" or "realism." The point is that the conceptual work of contemporary theorists is often sanitized from the concerns of working scientists and what counts as success in their respective fields. These immunization strategies are undercut at every turn in this special issue, and indeed, the methods, problems, and concerns of scientists and mathematicians (from theoretical biology, information theory, physics, and topology) are on full display in several of the essays collected here.

There is, on the other hand, another tendency in the theoretical humanities from which this project also wishes to steer clear. In the wake of the so-called speculative turn in the humanities, we find a persistent, if entirely overblown, faith placed in the hard sciences as a "foundational" enterprise – part of a decisive shift in orientation within the humanities in the name of the "real." Frustrated theorists and philosophers have managed to negate one set of organizing principles (those that underlie the situated practices of humans) and replace it with another: mathematical formalism (Meillassoux), or lifeless matter (Brassier), or abstract universalism and computational intelligence (Negarestani), or automation and Promethean design (Bratton).

Instead, the work done in the OPG meetings, and showcased in this issue, revolves around a genuine concern for scientific styles of reasoning, and in particular for the problems, concerns, and assumptions that animate scientific work. And what emerges from this engagement is not the ascendance of a new transcendental principle (or, what amounts to the same thing, a foundational bedrock) derived from the physico-mathematical sciences, but just the opposite: that theorists working in these scientific fields are searching for conceptual frameworks that can express the fact that certain material and energetic systems (living systems) exceed the computational and conceptual systems designed to understand them, a domain in which the ontological and the epistemological domains enter into a zone of strange (and unavoidable) entanglement.



This special issue is the result of multiple years of collaboration among a diverse group of scholars, scientists, and practitioners. This group came to be known as the Ontogenetics Process Group (OPG). From the outset, what distinguished this unruly collective seemed to be a shared nostalgia for an intellectual space where scientists, humanists, and artists could engage in theoretical exchange without the pressure of superficial “outputs” to satisfy administrators, mixed with an insatiable hunger for the formation of an interdisciplinary conceptual frame capable of responding to pressing questions emerging not just from biological and computational systems (explored here in the essays by Longo, Nocek, Thurtle, and Wolfe), but also from the domains of social and cultural practice (plumbed in the work of Kauffman, Bennett, Espelie, and Wild). As the “roundtable” conversation shows, while the focus of this issue is tilted toward the sciences, the group has a keen interest in asking after the system dynamics, principles of organization and development, and modes of coherence that might obtain in the domains of law, the economy, and so on – and the extent to which those might be illuminated by models from the mathematical and biological sciences.¹

This kind of interdisciplinary theoretical endeavor has a long history, of course, one that, in recent decades, has been largely occluded by the rise of Big Data, the neo-Darwinian paradigm and its obsession with the genome as an engineerable “book of life,” and the assumption that “hard,” tenurable scientific knowledge is fundamentally quantitative in nature. It’s entirely possible, however, that

EDITORIAL INTRODUCTION

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that hegemony will, in the longer view, prove to be misguided or, at the very least, oversold, and in that longer view, the OPG might be situated genealogically somewhere between the intellectual investments of the Theoretical Biology Club in the 1930s (organicism), the interdisciplinary ambitions of the Macy Conferences in the 1940s and 1950s (that included figures as diverse as Warren McCulloch, Gregory Bateson, and Margaret Mead), and the restless game-changing and institution-building work of the Santa Fe Institute in the 1980s and 1990s. From the very beginning, Stuart Kauffman, one of the original members of Santa Fe Institute, and a founding member of the OPG,

would often remark (and we're paraphrasing), "there is really something here that the complexity scientists over there at the Institute won't be able to get their heads around."

What Kauffman is referring to is the fundamental challenge that OPG researchers pose to what has become the lingua franca of theoretical biology: complex systems theory, on a quantitative and mathematical template. For all the descriptive and predictive power that the complexity sciences offer (the ability to compute feedback systems, recursive networks, emergent dynamics, etc.), they also presume that the living world in all of its modalities (biological, semiotic, economic, affective, social) can be reduced to finite schema of description that delimits in advance all possible outcomes. The mathematics of complexity function like a "grid of intelligibility" for physicists, biologists, economists, information scientists, sociologists, and now many humanists; they permit the sciences of the living and nonliving to speak the same language. What distinguishes this group of researchers, and this special issue of *Angelaki* in particular, is the breadth of disciplinary and methodological frameworks brought to bear on the possibilities and limitations of this proposition. More than this, what is proposed here are conceptual architectures for the living that are not only irreducible to physico-mathematical frames of reference but that are also as vital as the phenomena they wish to express. In short: life is more complex than complexity.

In a sense, this may not seem like an entirely new proposition for the theoretical humanities. There is a rich genealogy of continental thought that engages with the contemporary biosciences through the vital materialist philosophy of Nietzsche, Bergson, Deleuze, Guattari, Simondon, Canguilhem, and others (see Ansell-Pearson; Grosz; Braidotti; Thacker). Bennett, Nocek, Thurtle, and Epperson address these touchstones in their articles, with different angles of emphasis, to be sure. However, several features of the OPG's treatment of the biosciences and related scientific fields resist some of the unfortunate clichés that have come to

characterize humanist engagements with science, particularly under the broad rubric of "materialism."

On the one hand, and in the interest of a more robust and rigorous form of interdisciplinarity, this collection opposes the pervasive tendency to keep scientific abstraction and mathematical formalism at a safe distance from philosophical and critical reflection, even or especially when the former are essential to engage head on. For example, Bergson's vitalist critique of Darwinian mechanism (via the *élan vital*) has served as a rallying cry for many neo-vital materialists and contemporary biophilosophers, but it has very little to say about the actual work of evolutionary and developmental biology as such. Rather, this abstract principle of vital force contributes to an overly general critique of scientific abstraction that privileges a metaphysics of vitality over and against what is already an often rudimentary understanding of mechanism. Similarly, the Deleuzoguattarian fad of drawing on von Uexküll's ethology, Leibniz's calculus, and Jacob and Monod's *lac* operon involves only the loosest appropriation of the hard sciences. This may tell us about continental philosophy's motivations and interests in engaging the sciences, but it tells us very little about the practices of working scientists and how philosophy and theory can learn from them. The point is that the conceptual work of continental theorists is often sanitized from the concerns of working scientists and what counts as success in their respective fields. These immunization strategies are undercut at every turn in this special issue, and this is nowhere more evident than in the work of Longo, Kauffman, Epperson, and Sha. Indeed, the methods, problems, and concerns of scientists and mathematicians (from theoretical biology, information theory, physics, and topology) are on full display in their work. These perspectives augment the "second-order" observations and ramifications of scientific work for the larger social context in the articles by Espelie, Wolfe, Nocek, and Bennett, adding another layer of critical urgency to the many issues raised about the computational sciences and algorithmic styles of reasoning generally.

There is, on the other hand, another tendency in the theoretical humanities from which this project also wishes to steer clear. In the wake of the so-called speculative turn in the humanities, which has undergone a number of facelifts since its inception in the mid-2000s, we find a persistent, if entirely overblown, faith placed in the hard sciences as a “foundational” enterprise. The wager is that the theoretical sciences (which de-correlate thought from being) can deliver the “great outdoors” (Meillassoux) that has been apparently missing from post-Kantian philosophy. Of course, these realisms and materialisms, as well as their many offspring, were by no means the first philosophical programs to privilege scientific and mathematical abstraction (e.g., Badiou; DeLanda), but their efforts have contributed to a decisive shift in orientation within the humanities in the name of the “real.”

This story has been told many times, and there is no use recycling the history of its emergence here (see Mackay; Gratton; Harman), but what is nonetheless worth underscoring is that the “scientific turn” in the speculative humanities has less to do with philosophers and cultural theorists working alongside theoretical scientists, or engaging in genuine debate about scientific and mathematical reason, than with good old-fashioned humanists cherry-picking from the hard sciences (mostly physics, mathematics, and computer science). Frustrated theorists and philosophers have managed to negate one set of organizing principles (those that underlie the situated practices of humans) and replace it with another: mathematical formalism (Meillassoux), or lifeless matter (Brassier), or abstract universalism and computational intelligence (Negarestani), or automation and Promethean design (Bratton).

This is not to say that scientists, social scientists, and humanists have not been assembled in recent years to address the limitations of the computational sciences. An excellent example is the edited collection, *Beyond Mechanism: Putting Life Back into Biology* (Henning and Scarfe). At the center of this work is a commitment to using the underlying principles of process philosophy (and related conceptions)

as the basis for addressing what computational practices have so far been unable to explain: in particular, the *self* in biological self-organization. On the one hand, it is remarkable that theoretical biologists are drawing (and not superficially) on Whitehead, Peirce, and even Kant for conceptual clarity. But on the other hand, the topics they explore are circumscribed by the presupposed relevance of a process-based metaphysics of life. What’s more, continental genealogies of nonhuman process, ecology, and subjectivity are entirely missing from the collection. Other collections and volumes have attempted to explore similar themes, most notably, *Life and Process: Towards a New Biophilosophy* (Koutroufinis), but here too we find the already-presumed sufficiency of process philosophy, and a complete lack of engagement with other conceptual histories.

Instead, the work done in the OPG meetings, and showcased in this issue, revolves around a genuine concern for scientific styles of reasoning, and in particular for the problems, concerns, and assumptions that animate scientific work. (Here, for example, a problem internal to the discipline of biology – the fact, as Denis Noble has suggested, that for decades theoretical biologists and experimental biologists have had almost nothing to say to each other – has stakes and implications that can be *better* illuminated, perhaps, from outside the discipline itself, when philosophy and anthropology shed light on what counts as “real” “science” and how that, in turn, overdetermines what counts as “life” (Noble 169, 235–37).) And what emerges from this engagement is not the ascendance of a new transcendental principle or (what amounts to the same thing) foundational bedrock, derived from the physico-mathematical sciences, but just the opposite: that theorists working in these scientific fields are searching for conceptual frameworks that can express the fact that certain material and energetic systems (living systems) exceed the computational and conceptual systems designed to understand them, a domain in which the ontological and the epistemological domains enter into a zone of strange (and unavoidable) entanglement.

As Alicia Juarrero asks,

Does emergence therefore simply come down to an *epistemological* ignorance, to our human inability to exhaustively list every *ceteris paribus* and disjunctive condition (even though such an exhaustive set of conditions in fact exists and there is a 1:1 correlation between each fully specified set of conditions and corresponding emergent property?). (518)

And Kauffman's answer, in short, is that "it is impossible to predict emergent properties even in principle because the categories necessary to frame them do not exist until after the fact" (qtd in Juarrero 518). And this is where, as Wolfe suggests, what one might think of as the astringent force of a fundamentally deconstructive sensibility is crucial to doing justice to the challenge of complexity and resisting the temptation to extract yet another "final" version (whether realist or idealist, transcendental or foundational) that anchors the thinking of complexity and, in the process, evacuates it. This detotalizing impulse may take the form of deconstruction proper, or it may be found in Bennett's attention to the thick description of the practice-based entanglement of minding and mattering and the worlds they create (both micro and macro), in Longo's insistence on the specific boundedness of time and place of the biological organism, or in the theorization of the untailed evolution of the biosphere and the fundamentally circular and recursive logic of living systems that we find in Kauffman and fellow travelers such as Anna Soto, Alicia Juarrero, and, of course, Longo himself.

The site on which these investigations converge, then, isn't just complexity, but constitutively *irreducible* complexity, of the sort increasingly mitigated against in the WEIRD (Western, Educated, Industrialized, Rich, and Democratic) world ruled by "governmentality" and "medicalization" (to use Foucault's well-known terms), where "science" is increasingly seen *tout court* as *applied* science. That complexity may be converged upon from various directions, of course. From one orientation (the one given "goth" voice in Thurtle's essay),

difference, alterity, the chaotic, "noise," and so on is a desideratum, something to be liberated from falsely reductive forms of identity, recovered and valorized. For another orientation, it is a problem that systems of organized complexity have to figure out a way to solve if they are to persist in the world: not "problem" in the sense of "bad" but rather in the adaptive and pragmatic sense, as a puzzle or a challenge. Either way, yet another turn of the screw here is to recognize that this domain of alterity, "noise," and chaos is itself an enormous asset in the larger gambit called "complexity."

Order and noise (to use shorthand) are not opposites but are rather co-implicated, and the liminal zone where they converge is, for us, the zone of interest, one that requires a new kind of dynamic, non-reductive theory whose most familiar shibboleth in contemporary continental philosophy is probably "repetition with difference" and its variants. As Yuk Hui puts it,

Recursivity is not only a mechanism that can effectively "domesticate" contingency [...]; it is also a mechanism that allows novelty to occur, not simply as something coming from outside but also as an internal transformation [...] [T]he recursive mode can effectively integrate contingency in order to produce something new; in other words, it demands constant contingencies. (138)

But since the alterity or negativity of temporality is at the (non)core of this process on both the micro- and macro-levels – hence our emphasis on "dynamic" – we are dealing here not with "the identity of identity and non-identity" (as in Hegel), but rather "the *non*-identity of identity and non-identity," a logic that is "heterogeneous" (as Derrida puts it) "to the dialectic and the calculable" (116), to the logic of any identitarian scheme, one that Epperson's essay explores in cross-mapping theoretical physics and the work of Whitehead and Simondon on the processes of "ontogenesis" and "individuation."

If this introduction reads like it is preparing the genealogical and intellectual ground for the claims made by the OPG, then it is because spaces for such theoretical engagement do not yet exist. Rarely, if ever, do we see an

information scientist, a complexity theorist, a design and organizational theorist, a mathematician, a historian of science, an experimental filmmaker, an anthropologist of science and religion, a philosopher of physics, and a couple of theoretical humanists assemble in order to contemplate modes of living that are *more complex* than complexity. At the heart of this shared inquiry is a deep and sustained interest in biology, in questions of self-organization, morphogenesis, epigenetics, cultural inheritance systems (soft inheritance), downward and distributed causation, as well as the implications of quantum physics in these domains. But in taking these questions on board, especially in light of the work Longo and Kauffman have done on the limitations of complex systems science, two things become startlingly clear: (1) that cultural, political, and economic systems cannot be isolated from the physicochemical emergence of living phenomena; and (2) that the reigning models of complexity need to be paired with non-computational and non-algorithmic modes of inquiry in order to better express the unfolding of living worlds. And yet, just what relevance these extra-biological systems have and what modes of (non-algorithmic) inquiry are most appropriate (ethnography, mathematics, conceptual art, philosophy, speculative design) are not agreed upon and remain open for debate.

This lack of agreement should not be treated as a limitation, however. Where other anthologies, volumes, or working groups would demand a clear path forward, and might even insist upon formulating a “new science” out of the non-algorithmic study of the living, we maintain that this is precisely the style of thinking that leads to the metaphysics of life that we aim to critique. We therefore see the radical plurality of views, which do not always sit comfortably together, as a strength that forcefully demonstrates the resistance of the living to metaphysical capture.



note

I Somewhere along the way, OPG researchers realized that these conversations were too

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important to go unrecorded. But because we did not intend for these meetings to yield specific outcomes (like a publishable roundtable conversation), many conversations went unrecorded. We would like to pay tribute to those individuals who were essential to the development of the Ontogenetics Process Group, but whose utterances are not transcribed here. These individuals include: Erin Espelie, Helga Wild, Giuseppe Longo, Patricia Pisters, Wim Hordijk, and Peter Slood.

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introduction

Even in an age of omnipresent artificial light, we rely on the geophysical realities of the earth to divide our days. We spin around the earth's axis, rising with light, resting in dark. Within that daily framework we measure our moments in relation to the *meridiem*, or mid-day point. Anything that happens before the meridiem, *ante-meridiem*, or a.m., moves out of darkness while *post-meridiem*, or p.m., ushers us back into the black. This binary system of oscillating twelve-hour intervals – indebted in form to the sundial – links very closely to the pan-species evolution of an internal, biological clock.

Time-sensing is essential to our generational, cultural, and species' identities. In 1900, Georg Simmel tied relational time to the accelerated movement of money and the pace of city life. Yet our role as time-based beings goes beyond capitalism and urbanism. As Rebecca Solnit describes it in her 2003 article (later book), "The Annihilation of Time and Space," a multitude of mechanics shifted our timekeeping habits and species' positionality around the turn of the last century:

Before the new technologies and ideas, time was a river in which human beings were immersed, moving steadily on the current, never faster than the speeds of nature – of currents, of wind, of muscles [...] Work was done according to task and available light, and tasks varied from season to season [...] Time itself had been of a different texture, a different pace [...] It had not yet become a scarce commodity to be measured out in ever smaller increments as clocks acquired hands, as watches

erin espelie

IN-KIND DISRUPTIONS ***circadian rhythms and*** ***necessary jolts in eco-*** ***cinema***

became more affordable mass-market commodities, as exacting schedules began to intrude [...] (11)

And as first suggested more than a century ago by Ricciotto Canudo, representations of time became even more diverse as cinema, the "seventh art," burgeoned.

Amid these perceived shifts in temporality, we have continued to rely on the classic twelve-hour clock as icon and compass. The European city clock (Big Ben, for example); the Deira Clock Tower in Dubai; or the fictionalized skyscraping timepiece constructed for a clinging Harold Lloyd in *Safety Last!* (1923). Analog watches, alarm clocks, school clocks, factory clocks, grandfather clocks. These

in-kind disruptions

twelve-hour timepieces are linguistically ascribed with anthropoid features: a flat face, two hands, occasionally feet, and even a waist. In one anthropomorphic rendering, the photographer Philippe Halsman collaborated with Salvador Dalí in 1953 to create a literal chiron of clockface and man (“Dalí Clock Face, From ‘Halsman/Dalí’ Portfolio”). In the close-up portrait, Dalí dons clock numbers on his face, with the 12 upon his forehead and the 6 upon his jutting chin. Most jauntily, his left-hand mustache end points up to the 3 and his right-hand one greasily drapes down between 7 and 8. We are our own timepieces, replete with internal body clocks.

Timekeeping on an epochal scale has become a way of tracking the existence and fate of our species. In 1947, the *Bulletin of the Atomic Scientists* set up the Doomsday Clock as a response to global nuclear threats, inspired by a cover designed by the artist Martyl Langsdorf (Benedict). Her rendering, in the hopes of conveying urgency, set the time to seven minutes until midnight: seven minutes until catastrophic, apocalyptic destruction and self-annihilation of the human species. Until 2007, the rhetoric of the clock was dominated by war, weaponry, and the global nuclear arms race. More recently, other threats have intervened, including social media, though nothing as forcefully as “unchecked climate change” or “nearly inexorable climate disruptions.” On 23 January 2020, the new position was announced as 100 seconds until midnight – the closest yet (“Current Time”). The clock functions as a warning: do not let us move ourselves, by our own hands, so to speak, any closer to midnight.

12:00 p.m.: all hands point up

The middle of the day, solar noon, high noon, the showdown.

Hands up.

The time with the shortest shadows.

Lunchbreak for the natural-light (cinema)photographer.

All photosensitive lifeforms organize their lives by light, both in the biological and

ontological sense. Moreover, being situated on a planet with a twenty-four-hour sun cycle, most photosensitive species have evolved, in turn, to become time-based creatures that operate on a twenty-four-hour schedule of cellular organization. This geophysical link between our environment and our bodies is only recently being investigated in genetic detail.

Light sensitivity pervades four kingdoms of life, from archea to fungi, indicating a clear genetic advantage to being linked to light. Cyanobacteria likely gained the skill of telling time with their bodies first, 2.5 billion years ago, synchronizing to the dark–light cycles of the rotating earth (Bass and Lazar). Darkness was a time set aside for DNA repair. Daylight was a time for feeding, nourishment, and energy replenishment. So, too, nearly every human cell functions as a clock, with genes oscillating on and off based on exposure to light. The main body clock sits in the hypothalamus, in the suprachiasmatic nucleus, which connects to the optic nerve. In a 2016 review of new data, *Science* published the following summary of transcriptional clocks in humans:

The circadian system is organized hierarchically with master pacemaker neurons in the central nervous system entrained to light each day, in turn conducting a distributed network of local clocks expressed in most peripheral cells and tissues. Within the brain, the clock plays a role not only in maintaining the timing of sleep/wake cycle relative to light but also in many behaviors, including learning, reward, and neurogenesis. Peripheral tissue clocks are entrained to the brain clock, although feeding and temperature are dominant in some physiological settings. Peripheral clocks may also become uncoupled and desynchronized from the central pacemaker during aging, shiftwork, jet travel, overnutrition, obesity, or cancer. Circadian disruption and associated impairment in sleep contributes to the molecular pathogenesis of disorders such as metabolic syndrome, obesity, diabetes, autoimmunity, and cancer. (Bass and Lazar)

1:00 p.m.: cinema clock

In my film *A Net to Catch the Light* (2017), I look at the unraveling of the human circadian cycle due to the pervasiveness of blue light, notably between 440 and 450 nanometers. Light-emitting diodes backlight our computer and phone screens and they operate largely in the blue-light spectrum. Our retinal cells respond to this light by cueing the brain to stay awake. This kind of light, rather than nutritive, can be toxic and even increase aging of the retina. Synchrony of cells can be lost when bathed in such light, leading to some of the pathogenesis listed above. *A Net to Catch the Light* creates a chorus of Macintosh computer startup sounds – or “chimes” as Apple refers to them – from the 1980s to 2016. The sound mix also reverberates with the voice of Steve Jobs speaking in 1983 about entering an age when our predominant form of media was in the process of becoming the computer, replacing television and “even the book” (“The ‘Lost’ Steve Jobs Speech from 1983”). The film draws attention to the material and physiological effects of being in a new world of motion-picture viewing that relies primarily on emitted rather than projected light.

Viennese filmmaker Peter Kubelka eschews the digital and, if anything, has sought to lay analog filmmaking as bare as possible. In 2012, he insisted upon the importance of the astronomical connection to celluloid film projectors and film viewing:

[Cinema] consists of two main parts, one is the domesticated sun, the light; there is this strong light, which is of course a domesticated sun. It’s not too hot; it inhabits this space and it’s always burning like the sun, always giving light. The projector in front of this sun has this so called “shutter” which is a circle, turning on an axis, and which is half covered by black metal, and half is empty. So when it turns, in front of the static light, it alternates light and darkness. In general language, it creates day and night, and it turns in a speed, which makes it create day and night twenty-four times a second [...] Just very fast, day and night. (Budd)

All celluloid film projection recapitulates day/night cycles for Kubelka. Still, he probes the possibilities for extremism in three of his works of art – *Arnulf Rainer* (1960), *Antiphon* (2012), and *Monument Film* (2012). In all three, the film strips consist only of black and clear leader, organized in metrical form. The light–dark oscillation creates its own sound and silence through presence and absence on the optical track. A *New York Times* review suggested that the aforementioned work has “a minutely calibrated, filmic heartbeat” stemming from its “frame-by-frame artisanship” (Rapold).

Other filmmakers have attempted to break time down in formal, metric fashion on screen. The *Continuous Quantities* series by David Gatten derives its structure from a mathematical concept by Leonardo da Vinci, who yearned for a way to divide the hour “into 3,000 parts” (Blackburn 139). Gatten calculated that to be twenty-nine frames per second and has completed two films in the cycle, *Shrimp Boat Log* (2006/2010), with 300 shots, and *Journal & Remarks* (2009), with 700 shots. As described by Johnny Lavant after the 47th New York Film Festival, “[H]is steady sense of meter and bar [give] this piece its percussive [...] the Platonic form becomes reality; art gives way to life and stillness to movement.”

In 2009, the Dutch artist Maarten Baas created a sweeping clock: a twelve-hour performance of two humans literally sweeping trash into two lines on a beach in Italy. The two lines of trash become real-time moving hands of a clock, as the performers take exactly one minute to move the minute-hand to its next position. Baas has created other iterations of what he calls the “Real Time” series. Perhaps most widely viewed is his projection at Amsterdam’s Schiphol Airport, which launched in 2016 (Baas). In it, a man appears to be working behind a translucent clock face, painting the hands in real time. The man uses a rag to squeegee off the minute hand of the clock, then uses a mini paint-roller brush to apply the next minute hand. The illusion is perpetrated by a pre-recorded video that runs, of course, exactly twelve-hours in length.

in-kind disruptions

No discussion of cinema as clock would be complete without Christian Marclay, who premiered his twenty-four-hour work of art, *The Clock*, in 2010. Like Baas' work, it functions as a literal clock. Rather than mirror the shape of a twelve-hour clock, the video operates in digital and figurative fashion, composed as it is of roughly 12,000 unique moments from films. By using film history to pace our experience of time in the present, *The Clock* suggests that we cannot use cinema as an escape from time, even though we might look to Marclay's piece as a full day's respite from our own lives. Indeed, *The Clock* reminds us that we are in lockstep with the genre-conforming narrative tropes and familiar plots of Western culture that make the hours both monumental and routinized (noon, quitting time, midnight). Freedom comes only in snatches of untethered sound and, occasionally, the more elusive somnambulant dreamtime. Thom Andersen writes for *Cinema Scope* about his experience of *The Clock*:

We seem to live in an eternal present. Thus our reckless politics and our reckless destruction of nature. *The Clock* literalizes this condition [...] *The Clock* suspends time. Lived time is teleological, that is, directed to some goal, even if it's just eating lunch. Movies mimic this experience of time, and they try to intensify it by placing obstacles in the way of achieving these goals. Before you can go to lunch, you have to escape from an alien spacecraft. It is then a time of anticipation, a time of suspense. The characters who appear in *The Clock* are often obsessed by this vectorized time. Not only must they escape, they must escape within an hour, or ten minutes, or 30 seconds.

Rather than placing blame on the larger human condition, Genevieve Yue, in writing for *Film Comment* magazine, critiques Marclay's mainstream source material:

The people that populate *The Clock* are yoked to the clock. I would hazard that the obsessive minute-by-minute clock-watching is a function of the kinds of commercial films, along with the stray television show,

that Marclay selected. Mixed together in this way, *The Clock* reveals the rhythms of these accumulated genres, with attention to time governing and uniting a fairly predictable set of actions and outcome. (Yue)

In almost every review or account I have read of *The Clock*, writers have been compelled to relate just how much or how little of the twenty-four-hour cycle they witnessed. No one I encountered managed a full day's viewing. If circadian-rhythm studies have established anything, we know that disrupting sleep, sitting, and staring at a screen for twenty-four hours qualifies as unhealthy, if not ruinous, behavior. Thus, the installation itself impairs our internal clocks if watched in full. To experience *The Clock* as Marclay made it, we must disrupt our cells, add stress to our biological systems, and, at the very least, recall our corporeality. Marclay himself identifies *The Clock* as a *momento mori*, and a recent London reviewer extended the reference to the *vanitas* genre of still-life painting (Eisen).

I would venture that the piece, more than any durational film, may actually have the capacity to shorten the lives of any ardent viewers, accelerate the aging of their retinas, and disrupt their sleep. A cinema clock that alters our own internal clocks is mighty indeed in its haptic sway, and all the more powerful for its empty, yet alluring, narrative vectorization. We are not watching for reasons of being, affect, or empathy. Instead, we witness our own unwinding.

2:00 p.m.: cinematics

Filmmakers are constantly in search of new timekeeping methods to reflect and respond to current times. For "cinematic" film scholars, such as Barry Salt, James Cutting, and Kristin Thompson, trends in timing can best be assessed through the analytics of editing. This quantitative data-combing almost always focuses on Hollywood. As Cutting and his co-authors of the book chapter for *Psychocinematics: Exploring Cognition at the Movies*, explain:

[F]or the purposes of this chapter, we will refer specifically to popular, or Hollywood, films in our discussions of film and movies. This sample of films is particularly relevant because, in most cases, popular Hollywood films are made to mimic reality. Movies are projected in a way that movement appears biologically appropriate. The color in modern movies is intended to mimic color stimuli in the real world. From a young age, we learn the nuances of continuity editing, so much so that adults often fail to notice cuts (the junction of two shots) when viewing a movie. (Brunick, Cutting, and DeLong 2)

Mimicking reality and creating biologically appropriate movement are not aspirations for many artists. Still, the selected dataset allowed the authors to conclude that

there is little question that shot length has been decreasing over time. In an extensive review of over 7,000 films, Salt (1992, 2006) examined shot durations in Hollywood films from 1913 to 2006 and found a steady linear decline in ASD. This finding has been corroborated by Cutting, DeLong, and Nothelfer (2010) in their sample of films from 1935 to 2005. (Brunick, Cutting, and DeLong 3)

The authors proceed to examine patterns of shot duration as a way of varying tempo, rhythm, and general pacing, and yet they end on a note of insecurity, acknowledging that many of their critics believe that quantitative analysis does “a disservice to film studies.” Still, they believe readers’ perceptions will be enhanced by their statistics.

3:00 p.m.: avoiding parasitism

Virginia Woolf once wrote a scathing critique of how clumsily cinema translated literature. In speculating about cinema’s capabilities, she asked, “How would it walk erect?” In short, she believed that cinema was “parasitic” and the only hope for the artform would come if filmmakers embraced abstraction. Only by setting aside the obviousness of reality might filmmakers find a path forward for “the seventh art.” Woolf writes:

[S]ome residue of visual emotion which is of no use either to painter or to poet may still await the cinema. That such symbols will be quite unlike the real objects which we see before us seems highly probable. Something abstract, something which moves with controlled and conscious art, something which calls for the very slightest help from words or music to make itself intelligible, yet justly uses them subserviently – of such movements and abstractions the films may, in time to come, be composed. Then, indeed, when some new symbol for expressing thought is found, the film-maker has enormous riches at his command. The exactitude of reality and its surprising power of suggestion are to be had for the asking. (Woolf)

In light of Woolf’s comments, I want to suggest that there is a need today for film to play a role in providing shifts in tempo and scale. Our sense of time must be altered in connection with our species’ dystopian prospects. We need works that can adequately alter our sense of time, but not just as a warp-speed, ever-shortening series of shots. Nor is the allure of metrics enough.

As the effects of climate disaster play out over generations, how might the boundedness of discrete media reckon with such a timescale? Moreover, the inequity of those climatic effects upon disparate communities forces an even more complex cinematic reckoning. Such considerations stand in contrast to the plethora of post-apocalyptic optics currently offered in scholarly debates and the popular realm, which perpetuate the reductive and violent outlook of an erased, tabula rasa landscape.¹ How might artists, who have historically been tasked with the challenge of representing the ineffable, complicate this picture and add texture to it? Perhaps that which cannot be directly stated might be more fully expressed if sung or intoned or painted or danced. Stacy Alaimo, for instance, outlines the need for greater ecological consideration within the arts, in this way:

[P]erforming exposure as an ethical and political act means to reckon with – rather than disavow – such horrific events and to grapple

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with the particular entanglements of vulnerability and complicity that radiate from disasters and their terribly disjunctive connection to everyday life in the industrialized world. (7)

Some attempts to make manifest the abstract and entangled idea of environmental disruption have been quite literal. In 2008, for example, a Parisian-based duo, Helen Evans and Heiko Hansen, known together as HeHe, went to the Salmisaari coal-burning power plant located in a residential district of Helsinki, Finland, and “drew” a green-laser outline of a cloud, a “Nuage Vert,” on the actual plume of smoke above the plant, marking in real time over several weeks the amount of electricity locals used (“Nuage Vert”). Brother Nut from China, starting in 2015, vacuumed up “the air” of Beijing to create “smog bricks,” by which you can hold, taste, and smell the otherwise seemingly diffuse particulate that we ingest. The potency of these material projects stems from their site specificity, their time-based data visualization, and the equitable public availability of their materials, forming a barometer for real-time environmental impact. I want to extend these ideas fully into how cinema has been approaching environmental crises. Within this ever-morphing context of an anthropogenically degraded environment, the making of moving images, or any of the other arts, demands a consideration of ethics: of the materials we have extracted, modified, and reinserted into landscapes, as well as an understanding of the vulnerabilities of viewers to feeling inundated and ineffectual.

4:00 p.m.: deborah stratman

The free-fall of consumer excess is at the heart of Deborah Stratman’s film *O’er the Land* (2009). Guns, massive RVs, fire torches, cameras, and even scientific equipment – all of these objects feature prominently in the fifty-two-minute film. Stratman shows us the glut so many Americans have at their disposal, a glut even of freedom itself, freedom to

play with material fodder for purposes of distraction and entertainment. In contending with this surfeit, we must accept what appears to be inescapable loss and waste. In a kind of condensed allegory of this larger problem, one scene in *O’er the Land* takes us into a birdsong laboratory. The affect is particularly subtle in its haunting: a bird is seen in beautiful close-up, singing, then flitting, until the camera reveals the full situation of the enclosure – only a square foot of space. The bird struggles for a foothold and for room to flap its wings. The singing suddenly reads as distress.

In a more recent film, *Illinois Parables* (2016), Stratman pushes into deeper timescales, testing cinema’s capacity for prospecting the past. Sonically, she takes us back via the reenacted voices of Enrico Fermi, Ralph Waldo Emerson, Alexis de Tocqueville, and more. Historical texts come into conversation with present-day images, often unsettling ones. One of most indelible scenes is populated by yellow police tape and a sign indicating that deer have been attacking locals who dare to walk down the park’s cordoned-off path. The warning is both oddly funny, given our dominant relationship with cervine creatures, and also eerie. It echoes the 2009 novel *Drive Your Plow over the Bones of the Dead*, by Olga Tokarczuk, who imagines the possibilities of deer turning the tables and becoming assassins of targeted human hunters.

Michelle Puetz, at the Cinema, Nature, Ecology Conference at the University of Chicago in 2009, described Stratman’s films as follows:

[R]ather than telling stories, [the films] pose a series of problems, and through their at times ambiguous nature, allow for a quite complicated reading of the questions she is asking [. . .] [They] point to the relationships between physical spaces or environments and the very human struggles for power, ownership/mastery and control that are played out on the land, meanwhile questioning elemental historical narratives about freedom, expansion, security, and the regulation of space. (Stratman)

5:00 p.m.: nikolaus geyrhalter

In *Our Daily Bread* (2005), Austrian filmmaker Nikolaus Geyrhalter takes on similar dialectics. He seeks out some of the most mechanized sites of food production in Europe, from abattoirs to salt mines to fish factories. One of the most surprisingly unsettling is at a poultry farm. Thousands of yellow chicks, only a few days old, are launched into crates by a sorting machine that alternates between two settings. With each flick of the machinery, the chicks are shot projectile-like from a cannon. Although the chicks' fragility seems at odds with the harsh treatment, they rebound quickly and seem almost protoplasmic in their malleability. Another shock comes in the idyllic setting of a nut orchard: a machine rolls up to a massive old tree, embraces its trunk, and proceeds to shake the tree violently until all its nuts fall onto tarps beneath it. The act seems so gratuitous that it reads like a molestation. In a stroke of brilliance, Geyrhalter contrasts these images of food processing with the mild and often drab lunch and coffee breaks had by the food workers at their requisite locations. Cigarettes and meager sandwiches appear to be denuded of nourishment or comfort, let alone the potential for enjoyment. Our bodies become the mundane masticators, while the machines become the shiny objects of aesthetic fetishization by the camera.

Geyrhalter began his career as a still photographer; relying on that expertise, he refrains in his work from moving the camera or changing focus. Not unlike Peter Kubelka, he cuts with mechanical precision, suggesting that his camera is another one of those tools for slicing, piercing, and organizing the organic world around us, making it digestible for human consumption. Notably, in his film *Homo Sapiens* (2016), all shots clock in at exactly thirty seconds. And it is in *Homo Sapiens* that Geyrhalter most apparently establishes a different mode of coping with the current environmental crises. The metronomic quality of the editing quickly establishes a pattern that eases expectations from the viewer, allowing her to settle into a regular

rhythm and discover each image in its own right.

In a 2017 interview with Scott MacDonald, Geyrhalter says that he views “subjects and filmmakers” as a team, even if the subjects are landscapes absent of humans. In the making of *Homo Sapiens*, he wanted the film to feel “democratic,” allowing the viewer to have more agency.

[T]he audience is allowed to search for details in the image and to see what they can discover. Usually in film we just make a cut and go closer, telling the audience what detail to focus on – and I wanted to avoid that. (MacDonald 152)

The force of the film, I would venture, comes most of all from the removal of location specificity in the film or the credits, suspending viewers in a speculative future of the planet, hinting at a crossover into fiction and asking us to imagine the minutes and hours and days after the doomsday clock hits midnight.

6:00 p.m.: mikael kristersson

Swedish birdwatcher Mikael Kristersson has a most delicate touch in his depiction of the present. In his film *Ljusår, or Light Year* (2008), Kristersson operates in a lyrical and mythopoetic tradition. Shooting only in his backyard garden over the course of ten years, he condenses those years into four seasons. Although this trope might feel trite at this point in time, what differentiates his approach and establishes its relevance for the current context is the mastery he has over the space, as seen from the vantage of all the garden's inhabitants: wasps, birds, butterflies, spiders, bees, dogs, cats, potatoes, raspberries, chickens. The film is not, however, about showing different points of view or different subjectivities. Rather, I would argue, it is about drawing infinite connections to all forms of matter – living and inorganic. The perspectives or, better, the locations of the non-human (which are not “points of view” per se) seemingly drive the cuts, if not the movements, of the camera.

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This is the opposite of what Donna J. Haraway bemoans in her discussion of “crittercams” in *When Species Meet*:

How could a mentalistic “camera’s eye” narrative ever take hold in the face of such immersion in boats, sea spray, waves, immense whales and slippery dugongs, speed and diving, piloting challenges, team interactions, and the materialities of engineering and using the plethora of cameras and other data-collecting devices that are Crittercam? Indeed, the visual structuring of the TV episodes emphasizes bodies, things, parts, substances, sensory experience, timing, emotions – everything that is the thick stuff of Crittercam’s lifeworld. The cuts are fast; the visual fields, littered; the size scales of things and critters in relation to the human body, rapidly switched so that the viewer never feels comfortable with the illusion that anything much can be physically taken for granted in relation to oneself. Part bodies of organisms and technologies predominate over whole-body shots. But never is Crittercam’s audience allowed to imagine visually or haptically the absence of physicality and crowded presences, no matter what the voice-over says. The word may not be made flesh here, but everything else is. (254–55)

Kristersson has found a way – in an era that’s well beyond anthropomorphizing – to mete out a rendering of the world that shows true intersubjectivity, in the Husserlian sense. He manages to achieve this with a host of non-reductionist aesthetic choices made possible by his immersion in his own “lifeworld” setting at home, and by the fact that he was able to shoot over an extended period of time. Parachute filmmaking, traditional ethnographies, and even sensory ethnographic explorations cannot tap into these intricate interconnections that depend on extended temporalities for their depth of portraying a full ecosystem in time and space.

7:00 p.m.: endosymbiotic structures

In 2018, I made a film, *Inside the Shared Life*, which takes its title from a loose and poetic

translation of the Mandarin character for *endosymbiosis*. The film uses underwater sounds of marine creatures ranging from snapping shrimp to Weddell seals and blue whales. Yet the closest the images get to the ocean is a Petri dish and a womb. A human voice, namely Lynn Margulis, acts as our narrator, describing how she came to resurrect the idea of endosymbiosis, an idea originated and outlined by Ivan Wallin in 1927 (Margulis). She also insists, “We don’t want to name organisms based on the outcome of their relationships [...] You will never understand biology unless you look at it as community ecology.” The film attempts to mirror that ethic in form – a model of growth, adaptation, and malleability of non-autonomous identities.

As Kayla Anderson expresses it,

Anthropocene narratives coming from the art world seem to be most potentially destructive when they propose to do something, further reinforcing an attitude of human dominance over the planet [...] The ecological problems we face are not going to be solved by eco-art, representations of fake-nature or collections of plastic hybrids from polluted coastlines. (339)

Similarly, Shilyh Warren has forged a definition for eco-experimental documentary filmmaking as, “[engaging] less in a call to action than in the reorganization of perception: to experience time and nature in a new way is to potentially develop a new ethic towards the environment” (103).

8:00 p.m.: chirality

“Chirality” is a term in organic chemistry, coined by Lord Kelvin in his 1893 Oxford University lecture, that identifies an object unable to be superimposed on a physically realized mirror image. The human hand is an oft-cited example: the left hand mirrors the right hand, when facing palm-to-palm, but cannot be matched in three dimensions because of its asymmetry. An artwork always fails to match precisely with what it represents, however true to form. As Lukács writes, “Art, the visionary reality of the world made to our measure, has

thus become independent: it is no longer a copy, for all the models have gone” (67). Yet art, I would suggest, can have a chiral reality. Rather than being indexical, in the sense of Charles S. Peirce’s categories of signs, an artwork that achieves a transportation of place, a control of time, and its unique containment of space moves into a cinematic realm of what I see as chirality.

Tom Gunning writes on the drawbacks of indexicality in analyzing the photographic medium:

[I]t would be foolish to closely identify the indexical with the photographic; most indexical information is not recorded by photography. Long before digital media were introduced, medical instruments and other instruments of measurement, indexical instruments *par excellence* – such as devices for reading pulse rate, temperature, heart rate, etc., or speedometers, wind gauges, and barometers – all converted their information into numbers. Although a photograph combines both types of signs, the indexical quality of a photograph must not be confused with its iconicity. The fact that rows of numbers do not resemble a photograph, or what the photograph is supposed to represent, does not undermine any indexical claim. (40)

In separating indexicality from iconicity, I suggest here that there is a place for this term chirality, either linking those two ideas or acting as a substitute for how to consider the photographic signifier. In reconciling planetary changes with the representational tools available, there needs to be a greater focus on iconicity as well as an additional means of reference, such as chirality, which I believe can speak to the inversion that occurs in attempts to represent the corporeal as digital and emitted light.

The clock could become chiral, too, I would venture, if we step over the “doomsday” hour of midnight. The clock folds in upon itself if we declare the world to be over, and we enter a different time-sensing. If we declare the end of human time, the end of earth time by our metrics, then we make way for an alternate representation of the time to come.

espelie

9:00 p.m.: humankind cannot bear very much reality

“Where is the present?” asks William James in *Principles of Psychology*. “It has melted in our grasp, fled ere we could touch it, gone in the instant of becoming” (608).

10:00 p.m.: entrainment

Here is the moment of compression, when the clock appears to speed up. Our slide into the future appears impossible and the look back through deep time happens in a flash. We must match the hours of the clock.

11:00 p.m.: time signatures as a theory of everything

In order to prevent Woolf’s cinematic parasitism, we must activate the further potential of cinematic representation through in-kind perturbations and shifts in temporalities. Cinema – especially experimental eco-documentary – can respond to the new magnitudes of our time. Instead of moving back and forth from the local to the planetary, moving-image artists can suggest a more expansive investigation of space *and* time in order to learn from past and present experiences, to imagine more ethically durable futures. Sometimes that means staying in one place. Sometimes that means duration. Sometimes that means a metric edit.

Clearly there are no catch-alls, only timings.

12:00 a.m.: doomsday. the end of the world. the return

The poet Eleni Sikelianos writes:

Earth shows us how
a minute is round, an hour is, a day
Because it is round we cannot help coming
round
upon ourselves again (41)

In a time when philosophical thinking has shifted into posthumanism, new materialism, and object-oriented ontology, the countdown

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to the end of the human species might be reconceived as a celebration, a new beginning for the rest of the planet. The doomsday and apocalypse transforms into rebirth. The time signature changes and the planet gets a new start.

All hands point up.



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