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Unstill Life: The Emergence and Evolution of Time-Lapse Photography

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Film and Media Studies

by

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ABSTRACT

Unstill Life: The Emergence and Evolution of Time-Lapse Photography

by

James Stephan Boman

In seeking to identify cinema's unique powers, film theorists have frequently drawn attention to instances of temporal modulation. Whether slowing down the motion of a passing bullet or accentuating the bustle of urban traffic, the cinematograph's flexible framerate seems to reveal aspects of the phenomenal world to which we are otherwise blind. In more contemporary examples, this ability to vary film speeds can be subsumed into a broader range of visualization practices, and may prove especially pertinent to efforts to model, demonstrate, and mobilize responses to incremental climate change and other cases of what Rob Nixon calls "slow violence." In short, we find ourselves compelled, now, to engage innovatively with nonhuman temporalities—but now is also a good time to think *historically* about the roles different media have played in producing and organizing our relation to disparate timescales.

This dissertation considers the early history of time-lapse photography—a set of distinctively cinematic techniques which reduce framerates in order to condense slow-moving phenomena into vivid motion pictures. From the start, time-lapse techniques have been associated with the revelation of natural phenomena: the growth of flowers, the division of cells, the decay of fruit. These techniques have also long been associated with the middle ground between science and aesthetics—embraced by biologists and botanists for the sake of

recording important data, but also seized by film artists who wished to dazzle their audiences with uncanny spectacles of writhing life. In *Unstill Life*, I attend to both of these traditions, with particular attention to how these techniques were used in the life sciences around the turn of the twentieth century, and how the emotional force of this imagery both entailed and problematized questions of medium specificity. Embracing a wide understanding of time-lapse photography's iconographic roots, technical conditions, and epistemological analogs, I track this form of moving image through a variegated genealogy. These case studies include the tendentious history of "march of progress" illustrations, and other approaches to filling in and "animating" the fossil record; the metaphoric value of time-lapse tropes to the arguments of classical film theorists; the medial intersections of botany and photography; and how early cinematographers modulated framerates to explore their urban environs. Across these diverse cases, time-lapse techniques (along with their antecedents and analogs) were poised between an obligation to inscribe nature faithfully—an ideal of objectivity that was in some ways structured by the mechanical agency of photography itself—and a dream of picturing nature's secret machinations in previously unknown ways. In short, the power and point of time-lapse images involved both indexical fidelity and the wondrous appeal of a magical illusion—a visual sensibility that I characterize as an *unstilling* of natural phenomena. The central virtue of this modality of *unstilling*, I argue, lies in its potential to model, enact, or stimulate an altered relation between the viewer and her environment—to realize new *ways of seeing* our familiar-yet-unfamiliar world, ways of seeing that might prove consonant with the vital principles this simple technique disclosed.

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Introduction: Sped Up to the Rate of Human Desire

In the early pages of Richard Powers's 2018 novel *The Overstory*, there is a description of an unusual motion picture. His immigrant father, Jørgen, having planted three lonely chestnuts on his Iowa farm during the Civil War, John Hoel decides to start taking pictures of the sole surviving tree with his recently purchased Kodak No. 2 Brownie camera. The year is 1903, and John is inspired by his daughter's zoopraxiscope, a toy whose twirling animations of flapping geese and bucking broncos plants in his mind the germ of an indefinite project: "A grand scheme occurs to him, as if he invented it. He decides to capture the tree and see what the thing looks like, sped up to the rate of human desire."[1] John, who was born the year the chestnut tree was planted, "captures" his companion tree through a rigidly observed routine, a ritual that the narrator more than once likens to a religious observance. From the same spot, at the same time of day, on the 21st day of every month, he snaps a single image of the tree. A year of repetitive labor yields 12 photos which, flipped through, don't reveal much of anything; but John, possessed by the patient generative ethic of farmers, persists, willing to give the project as much time as it needs to bear whatever fruit it will, "as if he, too, might have another hundred years or two to document what time hides forever in plain sight" (12). In fact, John dies at the age of 56, but bequeaths his ritual to his son, Frank. Frank, in turn, hands the Brownie over to Frank Jr. before dying in WWI, and Frank Jr. carries the project on for decades before finally passing away himself and relieving his own son of the generational burden.

[1] Richard Powers, *The Overstory* (New York: Norton, 2018), 11. Hereafter cited in text.

As Powers narrates the circumstances of this seventy-five-year shooting schedule, he reflects on the dialectic of human and nonhuman drama it embodies. Most of the photographic work is taken up by Frank Jr., for whom the project is mostly an annoyance he bears for the sake of his father's memory. Occasionally, the ritual kindles a faint glow of inspiration in him, "thoughts he doesn't know how to have. . . . It's a monthly exercise in noticing a thing worth no notice at all, a creature as steadfast and reticent as life" (15). The third-person narrator likewise alights on how the project confuses the usual arrangement of story and backdrop: "The farm is to Frank Jr.'s back, each time he opens the lens. The photos hide everything. . . . Everything a human being might call the *story* happens outside his photos' frame. Inside the frame, through hundreds of evolving seasons, there is only that solo tree, its fissured bark spiraling upward into early middle age, growing at the speed of wood" (16). The tree planted by Jørgen, documented by John and Frank and Frank Jr., is finally and most fully animated for Frank Jr.'s grandson, Nicholas. Nick discovers an early affection for rifling through the stack of photos, flipping through the images forwards and backwards, peeling time back between thumb and forefinger. Seventy-five years of ritual photographs coalesce into a five-second film, "the oldest, shortest, most ambitious silent movie ever shot in Iowa . . ." (13); they also burrow into Nick's youthful mind, infusing his nighttime dreams, and even triggering his discovery of an artistic vocation. "Neither his grandparents nor his father could explain to him the point of the thick flip-book. His grandfather said, 'I promised my father and he promised his.' But another time, from the same man: 'Makes you think different about things, don't it?' It did" (19).

Powers helps us imagine a film we never actually see, though perhaps we have seen others vaguely like it: the branching life of a lone Iowa chestnut tree over four generations of

documentarists, its quiet growth presiding indifferently over the Hoels' offscreen loves and dreams, their trials and schemes and untimely deaths. "Each picture on its own shows nothing but the tree [Nick] climbed so often he could do it blind. But flipped through, a Corinthian column of wood swells under his thumb, rousing itself and shaking free. Three-quarters of a century runs by in the time it takes to say grace" (18). Indeed, this description in Powers's novel is just one of countless instances of time-lapse imagery surfacing in scattered regions of contemporary culture. Other examples are as plentiful and diverse as they are unremarkable. Time-lapse shots of traffic and weather patterns bridge scenes in reality TV shows and fiction series. In AMC's *Breaking Bad* (2008-2013), time-lapse inserts of Albuquerque street corners and New Mexico landscapes have the added value of thematizing (to the point of literalism) the show's concern with the mid-American meth economy. For the most part, though, similar time-lapse transitions in other programs do not seem to serve any definite purpose. Television commercials offer a steady diet of growing, flourishing plant life and clouds pouring across postcard-worthy landscapes. Credit sequences for movies and cable series showcase accelerated footage of impersonal urban bustle (as in the opening to Netflix's *House of Cards* [2013-2019]). Nature documentaries routinely astound us with jungles and other ecological niches creepily writhing to life.[2] Beyond these textual ornaments, which suggest that time-lapse is a minor, unremarkable, but pervasive subspecies in an unruly ecology of moving images, there are cases that garner more attention. Especially noteworthy are a series of DIY, amateur time-lapse videos posted to YouTube, which show a marked fascination with the human body's susceptibility to time:

[2] See Colin Williamson's discussion of John Ott's time-lapse work for Disney's "True Life Adventure" films, *Hidden in Plain Sight: An Archaeology of Magic and the Cinema* (New Brunswick, NJ: Rutgers University Press, 2015), 89-99.

users document the maturing of their children from infancy to adolescence, the course of a pregnancy from conception to birth, a gender transition, or simply several years of midlife greying, wrinkling, balding, and weathering.[3] These mortally attentive videos often elicit melancholic response, as if mourning the passing of time itself, eulogizing the hopeless desire to cling to passing moments, acknowledging how lived time collapses, in remembrance, into an indefinite blur. This effect is not so different from turning the pages of a family album; and now, especially, it is a mode of image production that requires as little technical savvy as a Kodak No.2 Brownie.

The Overstory's tree-growth flip-book is only one instance of the ubiquity of time-lapse iconography in contemporary culture, but there are aspects of this example that are unusually rich and revealing. To begin with, there is the fact that this example is *not* a moving image, but a literary description of one—a description which splits attention between the decades-long production of the flip-book and its incandescent power as a moving image. In reading a poetic account of the generation and impact of this time-lapse portrait, we are implicated in the intermedial nature of this kind of image. The roots of time-lapse imagery, after all, predate the invention of either cinema or photography, and can be found (among other places) in evocative passages by Goethe and Humboldt, who never saw or envisioned a flip-look like the Hoels', but who were nonetheless moved to imagine plants and trees growing before their eyes.[4] These literary roots were soon entangled with other media forms,

[3] Laura Horak, "Trans on YouTube: Intimacy, Visibility, Temporality," *Transgender Studies Quarterly* 1, no.4 (2014): 572-85; Jason Middleton, "Temporality and Pathos in Longitudinal Documentary," paper presented to Visible Evidence conference, Bloomington, IN, August 9, 2018.

[4] Cornelia Zumbasch, "The Metamorphoses of Ottilie: Goethe's *Wahlverwandtschaften* and the Botany of the Eighteenth Century," *European Romantic Review* 28, no.1 (2017): 7-20. This article also quotes a remarkably trippy description of plant movement from Novalis's romantic novel, *Heinrich von Ofterdingen*, in which the hero seeks and finds a mysterious blue flower: "Finally, when he wanted to approach the flower, it all at once

fertilizing the conceptual soil of photography in the mid-nineteenth century, and guiding the course of time-lapse illustrations in the lead-up to the twentieth. Mirroring the ecological connections signaled in *The Overstory*, cinema and the visual culture of the twentieth century have sewn their own fruits back into the soil of literary inspiration, supplying novels like Powers's with the now-familiar iconography of time-lapse films. The Hoels' flip-book is not just a memorable and evocative episode, but emerges as a structural metaphor for the novel itself, as it sets out to tell a story of human interconnection across continents and generations, bearing witness to human dramas from high up in the long-enduring foliage of trees, and figuring humanity's real and symbolic embeddedness in this dendritic ecology. The novel, like the time-lapse film it envisions, can only capture this generation-spanning story in the thinnest of slices, each of which, on its own, tells everything and nothing about the lives held in its frame. Meticulously rendered, assembled in a stack, and flipped through with human hands, however, these slices merge and give life to something else, something contained in and yet exceeding the contours of the static images.

"Time-lapse," then, names a form of moving image that radically condenses time for the sake of displaying movements so slow as to be invisible, or unnoticeable, to human eyes in ordinary circumstances. Through these images, we confront the thresholds of the visible world, compensating for invisibly gradual phenomena either by speeding *them* up, or by imaginatively altering *our own* status as natural observers—projecting ourselves into the position of a godlike, extraterrestrial, no-longer-human observer whose vision comprehends both time and space from a distance. As a number of early observers remarked of the

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began to move and change; the leaves became more glistening and cuddled up to the growing stem; the flower leaned towards him and its petals displayed an expanded blue corolla wherein a delicate face hovered" (12).

technique, time-lapse seems to do for time what the microscope and telescope had done for space.[5] But in doing so, time-lapse does not necessarily extend specific technologies, like optics or even photography; instead, the technique *spans* media practices, and in doing so, it transmits forms and iconographies between the written word, photography, cinema, and other modes of illustration. It is intriguing how the example Powers describes both is and is not an example of cinema, and how it confuses notions of authorship and agency. The inciting idea is putatively cinematic, a fusion of consumer photographic equipment and a popular toy for displaying simple animations. The physical medium through which this moving picture is achieved is still photography—still photography combined with the recursive logic of ritual and routine, so that each shot of the tree is made from the same spot, at the same time of day, at rigorously maintained monthly intervals. This formula is more than the point-and-click habitus of amateur photography, and distinct from cinema's analysis and display of live movement, something that Powers aptly compares to the farmer's hopeful and far-reaching confrontation with time and with nature's seasonal yields. The flip-book's aesthetic power and behavioral ethic belong both to cinema and to photography, and yet they are infused with the self-exceeding patience of planting and cultivating and waiting. The narrator's choice of words—that John Hoel is inspired to the photographic project "*as if* he invented it" (my emphasis)—undermines the primacy of human agency in the production of this kind of imagery. At least implicitly, it is the tree itself that provokes this form of behavior in human beings, the tree that dictates the program of time-lapse documentation, the tree that makes

[5] The term "telescoping," in the sense of "condensing" or "collapsing," aptly describes what time-lapse photography does to time; however, it is worth mentioning that whereas microscopes and telescopes enhance our view so that small bodies appear larger and distant ones seem closer, the logic of time-lapse imaging runs the other direction: it *expands* a temporal frame so that more information (more movement) can fit within it. It is not a close-up of time, but an extreme long shot.

John, Frank, Frank Jr., and Nicholas into partly unwitting, only half-consenting implements in the making of a self-portrait.[6]

Besides the multigenerational human and botanic agencies channeled into the flip-book, there are the imaginative streams that its time-lapse display further lets loose. As Nick's father puts it: "It makes you think different about things." For the characters involved, this means reflecting, however inarticulately, on how the tree's outward ways of being both resemble and totally outrun their human counterparts. In the narrative of the Hoel family, the memory of the flip-book is a sort of "primal scene," an image secreted from Nick's formative years, which germinates as an inscrutable nighttime dream before sprouting as the realization that he needs to become an artist.[7] The flip-book ignites ideas and inspirations that are not exactly contained in the evocative image itself, an incitement to think more generally about the diverse forms of natural life and natural wisdom that evolve around us, "hidden in plain sight" in that they happen too slowly, too quietly for us to notice. The time-lapsed tree is both a movie and a medium of a different kind, a viscerally stirring image that cannot perceive the finite horizons of human cares and human feeling, yet which conditions the novel's attempt to construe the complex patterns subsisting beneath human fates, and those ties that bind human lives back into the ecological, cosmic careers of trees.

This knot of concerns prompted by *The Overstory*'s chestnut tree flip-book—the indefinite space between still and moving images; the phenomenal and ethical encounter with nonhuman temporalities; how both technical media and growing flora alter our notions of art

[6] The notion that plants *use* people to achieve designs of their own is promoted in Michael Pollan's *The Botany of Desire: A Plant's-Eye View of the World* (New York: Random House, 2002).
[7] Adding to this tangle of fates is the fact that Nick's vocation (and, by extension, the time-lapse film) saves his life: he is the only family member to journey to Omaha on Christmas eve to see an exhibition of landscape paintings; the only one who, therefore, does not perish that night from a gas leak from an old propane heater.

and agency; and the dynamic between concrete media forms and the metaphors and dreams they somehow foster—are central to the aims of this dissertation. *Unstill Life: The Emergence and Evolution of Time-lapse Photography* is, most narrowly, an examination of the early history and theoretical significance of cinematic techniques for radically accelerating time. I am interested in how time-lapse techniques were appealing to writers who were trying to make sense of motion pictures as both a new art form and an instrument, or metaphor, for reimagining the modern world. Because this technique could present audiences with natural phenomena they had never seen before—flowers blooming, clouds streaking across the sky, crystals growing, and other elegant movements and migrations—it seemed to prove that cinema could be a *revelatory* medium. Time-lapse did for nature's seemingly-static bodies what cinema had done for still photographs: it *animated* them. But for time-lapse to be taken as an instrument of revelation, it was important that its imagery was more than a splendid illusion, or a graphical illustration; these movements had to be construed as *real*, as a *restoration* of misperceived phenomena to their natural life, in the same way that cinema restored and reanimated photography's arrested slices of life. To get a full sense of time-lapse photography's emotional, aesthetic, and epistemological value, then, I contend that we must account for its relationship to photography, and to long-running debates regarding photography's ontological grip on the real. In short, the poignancy of time-lapse imagery depends on our conviction that what we are seeing is *not* an illusion, but the correction of one: the conviction that the time-lapse apparatus has faithfully encoded and accommodates real, natural movements from which we are ordinarily alienated.

While these claims for time-lapse's power and potency frame it as an emblem of cinema as such, it is important to my analysis that these powers also imply and depend upon

other sorts of media, and a range of observational practices and imaginative experiences. Time-lapse's essential process-condensing logic is exemplified, as we will see, by pre-cinematic experiments with chrono-photography, evoked through non-visual media (like literary and poetic descriptions), achieved with great ease with new digital cameras, and yet conceptually and practically rooted in still, analog photography. This study therefore acknowledges time-lapse photography as a trans-medial phenomenon—a type of moving image that exceeds any specific technical configuration, a way of envisioning nonhuman temporalities that finds manifestations in a variety of concrete forms and practical means. Acknowledging how time-lapse visualizations are sourced in multiple forms of media, living and breathing in the gaps between them, means sampling the history and variety of attempts to picture invisibly slow movements, and related attempts to think across boundaries between visible and invisible phenomena. To be sure, *Unstill Life* considers only a partial and patchy sample of this variety; the upshot of this eclectic approach, though, is a richer sense for how cinema has interacted with other imaging protocols, both in conception and in practice, to confront invisibly gradual phenomena.

As this dissertation's subtitle signals, "emergence" and "evolution" are key terms throughout this analysis. However, while *Unstill Life* considers several contexts for time-lapse photography's technical emergence, the main thrust of this project is not to provide a *history*, per se, of time-lapse photography, nor to give a cross-section of its applications at a given place and time. Instead, I offer several ways of looking at time-lapse photography, exploring the full significance of beholding nature in this way, how these bewitching views relate to the technologies that produce them, the broader concerns potentially embodied in these movements, and the other sorts of connections and insights they might enable. I am

also interested in the host of ideas that were infused into the desire for, and ultimate production of, time-lapse motion pictures—ideas intimately involved with the meanings of "emergence" and "evolution" as such. Why should anyone have wanted to see plants, cells, clouds, or cities move in this accelerated way? What dreams were fulfilled, ideologies served, or epistemological queries answered by these images? Most important to this study, though, is the aesthetic *power* of these motion pictures, and how aesthetic qualities nourished the practical, artistic, and imaginative resources of those who encountered them. What kind of imaginative life have time-lapse images loosed upon the world in the decades before and after the emergence of cinema? What is the nature of its entanglement with certain enduring lines of care, our notions of process and agency, of our power to imprint, or be imprinted by, natural artifacts? How do these images participate in our concepts of nonhuman temporality, nonhuman witnessing, and natural historical evidence? How do they enable analogies across scales of being, show the interconnections among living things, and between lifeforms and their environments? These questions are what I mean by "the imaginative life of images," and I want to pursue them at the same time that I address, through the example of time-lapse photography, the conceptual relation between cinema and other forms of "media," widely construed.

In drawing out these diverse perspectives on time-lapse—its theoretical significance, its technical components, its conceptual and metaphorical attachments—one of my main goals is to flesh out this technique's most obvious virtue: that it allows us *to see in new ways*. Each chapter explores this theme in a different concrete setting, ask *what* a given time-lapse image allows us to see, what is different or "new" in seeing it *in this way*, and what might be accomplished by this different form of vision. Across these chapters, time-lapse imagery

seems again and again to be concerned with different scales and expressions of *life*, and the significance of these animated views is often a function of how they mobilize new forms of analogies and correspondences. We might say that the language of time-lapse photography centers revolves around *analogy*. The sorts of analogies figured in, or provoked by, time-lapse images potentially help us think differently about a range of timely concerns—about the nature of agency, about the relation of human experience to nonhuman timescales, about the relation between the visible and the invisible, about the nature of mind, about the boundaries between life and mere matter. This conceptual and aesthetic terrain consistently returns to ideas about life, its germination, and its organization. What time-lapse photography promises to *unstill* are a range of life's visible manifestations and, more complexly, how we conceptualize life—how life emerges, and evolves, according to the miraculous records afforded by time-lapse media.

Cavell, Film Theory, and the Media of Movies

Unstill Life seeks a pluralistic understanding of time-lapse imagery, examining how this mode of envisioning relates to underlying techniques and adjacent media forms, with an eye to its distinctive significance as an instance of cinematic display. Seizing upon time-lapse photography's "emergence" means articulating the multifaceted ways in which motion pictures adapted and innovated upon earlier tactics for thinking about nonhuman timescales. This project is especially concerned, though, with the sorts of things time-lapse visualizations were supposed to *do*, the concrete research aims they were meant to advance, and the ideologies and cultural values this imagery put into motion. These ideas relate to notions of agency and automatism, modes of analogy and interconnection, the horizon between the

visible and the invisible, the philosophical matrix of evolutionary theory, and how "life" is articulated through the biological units of cells, embryos, and organisms. Time-lapse experiments were informed by these epistemological fields, and became important reference points in negotiating ideas within them. Often, this broadly philosophical importance was focused into time-lapse's local importance for questions of film theory. Imagery of plants growing, buildings sprouting from their foundations, and cells dividing epitomized cinema's vocation as a revelatory medium, especially for film theorists of the 1920s, '30s, and '40s. These spectacular images could reorient, and so renew, our perception of the physical world. Time-lapse techniques also dramatized film's uncomfortable relation to notions of illusionism and iconic representation, and I will argue that their intuitive, visceral appeal depended in some measure on their ontological intimacy with evolving nature—the feeling that they were encoded by nature itself, in complicity with the camera's intermittent exposures.

But besides these significant affiliations with the concerns of "classical" film theory—film's disputed ontology, its revelatory powers, and its specificity as an artistic medium—the spectacle of time-lapse imagery spurs reflection on cinema's relation to other media forms. It is a form of motion picture with intensely intermedial implications and possibilities. These implications include its pronounced relation to *photography*, its emphatic impression of *unstilling* the solitary photographic image. Contemporary artists have seized upon this modality of unstilling, as in Sam Taylor-Wood's gallery installations *Still Life* (2001) and *A Little Death* (2002). Composed to resemble old-fashioned still life paintings, it is only as one pauses a moment before *Still Life* that one realizes that it is a time-lapse video display. The healthy, buoyant orbs of fruit begin to wither and wilt, the orange

glow gives way to spreading brown splotches, a gauze of mold covers the top-most fruits like a halo before covering the whole array. Even the table supporting the glass bowl of fruit becomes an accessory to its putrefaction, pooling with unnameable deathly liquids. This nominally "still" image thus comes to uncanny, anarchic "life" through the movements of rot and decay; life is registered through the signifiers of its dying. As much as this short film exemplifies the radical difference between moving images and still ones, it does so by dramatically *negating* the conventions of artistic stillness. Time-lapse is identified, in this piece, as not just a form of motion picture, but as a mode of *unstilling* objects, settings, and images we are used to seeing in stasis.

As an emblem of unstilling and reanimating, of restoring the unnaturally fixed icon to dynamic life, time-lapse's phenomenology suggests less an illusion than a form of demystification. Paradoxically, it denatures our perception of the natural world, calling into question our habits of looking and the reliability of our faculties. The time-lapse display insists on the sense of restoring a still *image* to natural motion and so, by extension, associates our habitual perception of slow-moving phenomena with the illusionism, the false stasis, of the still photograph. This should remind us of other sophisticated strategies that image-makers have contrived for correcting the world's semblances of stillness. Time-lapse is prefigured in a host of illustration techniques—tree diagrams, sequential drawings, fossil charts—that are rooted in the inquisitive handling of natural forms, acknowledging that trees and fossils and strata also encode time in ways measured by their peculiar forms of agency. Time-lapse images are one node in this cluster of confrontations with nonhuman temporalities, one entry point to the earth's polyphonic rhythms. One way to account for this worldly encoding of time, and for its stimulating effect upon those who notice it, is to say

that trees and fossils are themselves media—instruments and instigators for structuring our knowledge and experience of time. To continue this line of thought, we might further suggest that time-lapse techniques *remediate* nature's own time-marking designs. In this study, I will have occasion to entertain the implications of these sorts of analogies between time-lapse imagery and organic temporal markers, and especially how modern techniques for animating deep time draw upon, and teach us to notice anew, the medial qualities of plants and fossils and landscapes. These examples situate time-lapse media among a host of vital forms that inhabit time and space in ways radically different from the experience of modern humans.[8]

While these mythic, metaphoric, and material entanglements with organic forms are key to the significance of time-lapse imagery, *Unstill Life* is mindful of the specific technical means through which these associations are explored, as well as the genres of imagery they ultimately produced. These means include experiments with photography, as well as strategies for sequencing photographs in ways that extend its spatial indexing to the contours of time. Often this sequencing entails clockwork mechanisms (or devotional routines of the sort described in *The Overstory*). As a cinematic display, it likewise entails projection and the synthesizing operations of the human sensorium, that fleshy apparatus which finally transforms twenty-four frames per second into continuous phenomenal movement. These variable components for effecting time-lapse imagery, I argue, relate significantly to the analogies and interconnections and animistic speculations that this imagery tends to evoke.

[8] James Leo Cahill also emphasizes this tendency of scientific imagery to push against the grain of anthropocentrism—a tendency he characterizes as "cinema's Copernican vocation." *Zoological Surrealism: The Nonhuman Cinema of Jean Painlevé* (Minneapolis: University of Minnesota Press, 2019).

How, then, to articulate and theoretically account for these connections between time-lapse's technical basis, its generic subjects and modes, and its thematic associations?

To this end, the film theory of Stanley Cavell, and especially his unusual approach to the notion of "media," is instructive. Writing in the 1970s, well after the heyday of classical film theory (with its concern for ontology and medium specificity), Cavell speaks with seeming naiveté about film's "physical medium," i.e., its basis in sequential photographic exposures and their reprojection upon a large, flat screen. Cavell grants that these material determinants are of fundamental importance to film's aesthetic viability, and even weights them with philosophical consequence. Film, for Cavell, is rooted in photography's technical basis, whose automatic manufacturing of pictures makes it a medium of ontological confusion and metaphysical distress.[9] How, after all, do we name the relation between a photograph and what it is *of*? How do we account for the experience of seeing something (in a photograph) that we cannot be present *to*? Classical theorists had divined philosophical insights from the bare functioning of the photographic apparatus, and prescribed aesthetic strategies based on the medium's ontology. Cavell, however, reverses this deterministic equation. Reasoning that we can only truly see what a medium's material base *is* by considering the way it is featured, or acknowledged, or activated, in art works that matter to us. In the field of modernist painting, Cavell considers the example of Jackson Pollack. Pollack did not just find ways to acknowledge what previous traditions of painting had taken pains to conceal—the fact that the art of painting depends on the material properties of paint and brushes. Pollack *made* the materiality of paint into a lever of aesthetic appreciation,

[9] Stanley Cavell, *The World Viewed: Reflections on the Ontology of Film*, enl. ed. (Cambridge, MA: Harvard University Press, 1979), 18. Hereafter cited in text.

"gave point" to the goopiness and fling-ability of oil-based paints: "Painters before Pollack had dripped paint, even deliberately. Pollack made dripping into a medium of painting" (31-2). He discovered, in short, a way to make those properties and those practices *matter* to beholders of his art.

As Cavell puts it, specifying "the unique possibilities of a medium" means realizing that those possibilities are in no sense *given* by physical materials; rather, they are worked up, or discovered, through artistic practice. "To make them 'possibilities of the medium' is to realize what will give them *significance*" (31). If we want to know about the features of film's physical basis (the grain of the film, say, or the automatic spooling of celluloid), our task isn't to inspect and analyze these material components, but to examine how film artists do (or don't) articulate those materials by endowing them with aesthetic significance. For film, the technical basis—the "succession of automatic world projections" (72) as Cavell comes to call it—satisfies (and so reveals) the philosophical wish to "view [the world] unseen" (40). But what enables this metaphysical diagnosis are the artistic expressions that infuse significance into photography's automatisms—expressions which are articulated through recurring and iterative cycles, genres, plots, stars, and types which, Cavell confusingly insists, are also "the media of movies" (60). Cinema is a philosophical machine, but only thanks to its successful artistic expressions and sensitive acts of criticism.

Cavell's film theory argues a version of medium specificity—and indeed, his definition of cinema problematically excludes cartoon animations. But his reversal of the medium specificity equation allows a seismic reshuffling of our sense of how media matter, and how their significance dialectically reveals and depends upon their material base. While *Unstill Life* is not, finally, committed to the argument that time-lapse photography is a

distinct medium, or a medium of cinema (as Cavell might put it), I *am* interested in the materials, agencies, and technical protocols that underwrite these marvelous motion pictures; more pointedly, I am interested in how these techniques are revealed and imbued with significance through the generic iconographies of time-lapse films. Examining the pragmatics of time-lapse procedures—whether via smartphone applications, water clocks, or religiously observed photographic routines—can and should be pursued in tandem with a reading of time-lapse's recurring genres, uses, themes, and tropes. Criticism is a pathway to theory, and a series of close readings will help me articulate the relation between these technical components and the ideas time-lapse imagery ultimately mediates. Where I part ways with Cavell most clearly is in his preoccupation with works of *art* per se. For me, while I am deeply concerned with aesthetics and how the aesthetic aspects of time-lapse imagery participate in the generation and articulation of thought, most of the examples I consider do not come from the domain of art. In fact, a great deal of my examples are drawn from the sciences, from research films and popular science films and nature-themed documentaries, and especially in connection with the life sciences—biology, botany, evolutionary theory, cytology, paleontology, embryology, and ecology. In approaching scientific practice, experimental techniques, and epistemology from the perspective of the humanities, I broach another set of other methodological questions and wade into an important, growing subfield of film and media studies.

Film, Media, and the History of Science

Many of the examples dealt with in the chapters of *Unstill Life* come from scientific research, or from popularizations of science. These examples include early experiments with

microscopes, high-speed ballistic photographs, groupings and analyses of fossils, tree diagrams, embryonic series, botanical illustrations, the time-and-motion studies of Muybridge, Marey, Janssen, and Gilbreth, and of course a collection of scientific time-lapse films depicting plant growth, microbial interactions, crystallization, and embryonic development. These examples are necessary to building up the perspective on "time-lapse" that *Unstill Life* seeks—a type of image epitomized as a cinematic display, but whose significant manifestations extend well beyond the technical protocols of celluloid or the phenomenology of motion pictures. Time-lapse suggests both a kind of visual display and a constellation of representational *logics*: the logics of photographic exposure, intermittency, clockwork, and cellular resynthesis. The natural sciences were not the only domain in which time-condensing images and logics were pursued, but they provide the richest and most durable archive of such examples, especially in the decades before and after the invention of the cinematograph.

In raiding the instruments and iconographies of science, *Unstill Life* is mindful of the scientific principles and disciplinary agendas that were attached to them in their historical context. To this end, I draw routinely on scholarship in the history of science and technology. This literature helps maintain a due respect for the epistemological frames from which these images emerged and which, both literally and figuratively, they helped to animate; but it is also, in sometimes surprising ways, a literature that adds a needed dimension to the field of film and media studies as a whole. Scientific devices and research protocols not only (as in the dramatic case of cinema's development out of time-and-motion studies) prefigure and prepare the way for the mature infrastructures, technologies, platforms, communications networks, and artforms that media scholars discuss; they also demand

attention as media forms in their own right. Historians and sociologists of science have taken steps in this direction, as in Martin Rudwick's classic study of illustration methods in geology, or Bruno Latour's influential discussion of how scientific agendas depend upon concrete and readily exchangeable icons.[10] But these studies (and others in their spirit) have yet to be fully absorbed as contributions to *media studies* more broadly, vital counterparts to the popular cultural functioning of television, radio, video games, or the internet.

There is, in fact, a small but rich (and growing) interdisciplinary subfield centered on the interactions and exchanges between science and cinema, particularly in the first decades of the twentieth century, and particularly as exemplified by research films and popular science films. This subfield includes scholars of film and media like Scott Curtis, James Leo Cahill, Oliver Gaycken, Kirsten Ostherr, and (before these more recent works) Lisa Cartwright, who have (respectively) published monographs on the disciplinary significance of science films in Wilhelmine Germany, the films of Jean Painlevé, the aesthetic of wonder articulated in early popular science films, the institutional circulation of films on contagion, and the presentation of the body in medical films.[11] This subfields also includes a group of science historians who regularly engage with motion pictures, like Hannah Landecker, whose attention to the techniques and iconographies of cell science provocatively nominates cell cultures as, themselves, technological media of sorts;[12] and Jimena Canales, whose study of

[10] Marin J.S. Rudwick, "The Emergence of a Visual Language for Geological Science 1760-1840," *History of Science* 14.3 (1976): 149-95; Bruno Latour, "Visualization and Cognition," *Knowledge and Society* 6.6 (1986): 1-40.
[11] Scott Curtis, *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany* (New York: Columbia University Press, 2015); James Leo Cahill, *Zoological Surrealism*; Oliver Gaycken, *Devices of Curiosity: Early Cinema and Popular Science* (New York: Oxford University Press, 2015); Kirsten Ostherr, *Cinematic Prophylaxis: Globalization and Contagion in the Discourse of World Health* (Durham, NC: Duke University Press, 2005); Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis: University of Minnesota Press, 1995).
[12] Hannah Landecker, *Culturing Life: How Cells Became Technologies* (Cambridge, MA: Harvard University Press, 2007).

the technical and conceptual construction of instantaneous time, the "tenth of a second," encompasses examples from photography, chronophotography, and cinema.[13] This literature is both a source of important examples for my own study, and a model for building conceptual and disciplinary bridges between the natural and human sciences. Like many of these scholars, I want *Unstill Life* to rethink the aesthetic importance of science films, and to help supply a fuller picture of what cinema has been and what it has done.[14] Where I depart from these studies is that, rather than focus on a specific scientific filmmaker (like Painlevé or Percy Smith), institutional context, or disciplinary agenda, I am focusing on the early life and career of a specific imaging technique, and how this technique evolved and was inflected across different technical protocols and disciplinary contexts.

Chapter Breakdown

The dissertation consists of four chapters, each of which centers on a distinct cluster of philosophical and theoretical concerns, reading these concerns through several recurring genres of time-lapse imagery. The first chapter, "Time-Lapse and Photography: Realisms, Revelations, and Affinities," works toward a specification of time-lapse's relation to reality—especially its fixation on living bodies and organic processes—by bringing it into focus within the optic of film theory, with an emphasis on accounts of cinematic *realism*. In recent years, with the rise of digital imaging technologies, much of the conversation about realism has been channeled into disputes over *indexicality*, especially the question of whether

[13] Jimena Canales, *A Tenth of a Second: A History* (Chicago, IL: University of Chicago Press, 2009).
[14] Accordingly, this project is also contributes a perspective to the literature on "useful cinema." See Charles R. Acland and Haidee Wasson, eds., *Useful Cinema* (Durham, NC: Duke University Press, 2011); and Vinzenz Hediger and Patrick Vonderau, eds., *Films that Work: Industrial Film and the Productivity of Media* (Amsterdam: Amsterdam University Press, 2009).

digital images imprint physical reality in the same ways, or with the same appeal to social conviction, as analog photography does (or did). I wade briefly into these debates because of how time-lapse photography insists on *time* as part of what its technical base imprints, and how this is central to time-lapse's attraction as an illusion that *reveals* contours of reality that are otherwise hidden in plain sight. Indexical realism and phenomenal revelation emerge, here, as theoretical concerns that are joined at the hip, and they will orient how I develop time-lapse in the chapters that follow. I cap the chapter, however, by considering how time-lapse photography's indexing and unveiling of natural process prompts consideration of another, comparatively less explored concept of film theory: that of affinities. In his late *Theory of Film*, Siegfried Kracauer envisioned film as a medium that not only reveals physical reality anew, but which is itself revealed by the sorts of phenomena to which it bears an apparent, intuitive attraction. Time-lapse, too, is a medium of film whose nature is suggestively modeled by the phenomena it documents. Not only is the functioning and logic of time-lapse imagery somehow *like* the growing plants and self-constructing buildings it renders, but it is a form of moving picture that enables and encourages other sorts of visual analogies, especially analogies based on forms of *movement*. Time-lapse displays often exploit our capacity for discovering provocative analogies and correspondences between otherwise disparate things, and in studying this visual grammar based on dynamic analogies, we can better appreciate the conceptual bridgework enabled by moving image media more broadly.

The second chapter, "Marking Evolutionary Time: Marches, Fossils, and Embryos," yokes together a series of attempts, both scientific and vernacular, to picture the metamorphic movements theorized by evolution—especially the serial images offered up by "march of

progress" iconographies, by fossils, and by serial diagrams of fetal growth. These examples are pointedly taken from outside the techniques of photography and animation; nor is any of them a "moving image" per se. But each of these examples refers to the sorts of invisibly-gradual phenomena that form the subject-matter of later time-lapse imagery, visualizing life's diverse nonhuman timescales; and each of them speaks to the complex interplay of capture (or indexing) and representation that factors into the emotional power of time-lapse animations. Comparing the ways in which fossils and photographs imprint natural forms and index the flow of time, I tease out the analogous ways in which these media encode and figure time, arguing that they in fact *embody* time and process, and that this representational logic is crucial to what early practitioners desired from time-lapse imagery—especially the frequently dreamt-of animations showing evolutionary transmutation as a fluid and enlightening display.

The third chapter, "Clockwork Gardens: The Mechanics of Photography and the Intelligent Powers of Plants," focuses on one of time-lapse photography's earliest and most enduring subjects—the spectacle of plant growth—and considers how this image of the metamorphosing plant mediated ideas about imagination, creative process, and unconscious agency. I consider this imagery's roots in the romantic movement's preoccupation with subterranean organic agencies as metaphors for the mysterious course of inspiration within human minds—a process sourced in nature and in important respects advancing unconsciously. I relate these poetic and scientific speculations, and their association with pictures of botanic growth, to earlier encounters between plants and photography, especially the botanic photograms that were pursued enthusiastically by technical pioneers like William Henry Fox Talbot and Anna Atkins. I assess how both photograms and early time-lapse

films complicate our sense of how technology, organic process, and artistic intervention have determined the resulting image, but how this complex interplay of causative forces focuses aesthetic appreciation on qualities of *contact* and attunement between human and nonhuman agencies.

Chapter 4, "Filming at the Speed of Life: Urban Rhythms, Experimental Impulses, and Organismic Vision," offers a close reading of Hilary Harris's experimental city symphony of New York, *Organism* (1975). Coupling time-lapse studies of urban systems with microcinematography sampled from medical films, Harris seizes upon an experimental ethic that animated both the camera-equipped cell biologists of the early 1900s and the avant-garde filmmakers who made city symphonies in the years between the world wars. Building on Brian R. Jacobson's account of early cinema's "infrastructural affinities," I argue that both scientific researchers and urban geographers were animated by a desire to see their subjects as complex yet coherent wholes, an "organismic vision" suggested by the function of the time-lapse apparatus and, in an important sense, instructively realized in Harris's film. This chapter also offers a tentative synthesis of the themes and capacities identified in each of the first three chapters: the analogy-building affinities attested in Chapter 1; the representational combination of indexicality and iconicity highlighted in Chapter 2; the self-realizing attributions of mindfulness described in Chapter 3; and, capping these, the importance of our own sensuous implication in these time-lapse renderings, our involvement in a holistic, organismic vision. Not only is the reality of what time-lapse documents *given* by our capacity to note new, outrageous, profound analogies, but that capacity should itself be understood as part of the vital, organismic complex imagined in, through, and by means of experimentation with time-lapse cinematography.

Chapter 1:

Time-Lapse and Photography: Realisms, Revelations, and Affinities

Walon Green's 1978 documentary *The Secret Life of Plants* brings together crackpot science and experimental aesthetics in theoretically provocative ways. During its limited theatrical run in 1978, one critic compared *Secret Life* to Green's two previous efforts, placing the film "in the tradition of 'The Hellstrom Chronicle' and 'Chariots of the Gods,' using the resources of the screen to 'prove' hypotheses."[1] Where these predecessors had argued, respectively, that "none of us will survive the insects" and that "there have been frequent extraterrestrial visitors to Earth over the centuries," *Secret Life* contended that plants, despite their sedentary appearance, are lively, sentient, and deeply intelligent beings. As the reviewer quizzically put it, "The root notion, so to speak, is that there is a universal consciousness, a kind of higher pantheism linking all animate things."[2] It is difficult to say just how seriously we are supposed to take the film's argument, which it had adapted from Peter Tompkins and Christopher Bird's controversial 1973 bestseller, also titled *The Secret*

[1] Charles Champlin, "MOVIE REVIEW: Talking It Over With the Plants," *Los Angeles Times*, Dec 13, 1978. Green had previously earned an Academy Award for Best Documentary Feature for *The Hellstrom Chronicle* (1971), and so *Secret Life* was given a limited run in 1978 to secure Oscar eligibility. When the film failed to earn any nominations, Paramount, the distributor, canceled the film's wide release. Nevertheless, the film has maintained a kind of cult interest over the years (due in large part, it seems, to Stevie Wonder's much more successful soundtrack album, *Journey Through "The Secret Life of Plants"*), and recently became available for streaming on Netflix and iTunes. The film's production history is synopsized at the AFI's online feature film catalog: http://www.afi.com/members/catalog/DetailView.aspx?s=&Movie=56998 (last accessed December 19, 2016).

[2] Champlin, "Talking It Over With the Plants."

Life of Plants.[3] Where Bird and Tompkins presented their theory of plant consciousness as the product of serious, unfairly maligned science, Green's film presents a liberal blend of visual evidence and visual rhetoric, in a tone that wavers between clear-eyed sincerity and winking irony. The film's case studies range from dubious laboratory studies (plants wired up to polygraphs) to New Age spiritualists (who speculate into the feelings of the plants in their community plots) to increasingly bizarre amateur experiments (a woman patiently teaches a potted plant the Japanese alphabet).

The film is most impressive and most eloquent when it presents plants, not in their odd communion with human caretakers, but living out their "secret" lives. To be sure, tropes of secrecy or privacy have long been commonplace in wildlife documentaries, placing the educative value of its footage (nature captured "in the raw") on a continuum with ethnography, pornography, and the voyeuristic pleasures of narrative film.[4] The private communities of plants, crystals, and microbes are in some sense no different, even though (or perhaps all the more because) we do not customarily think of them as beings endowed with the right to privacy. In this case, the sense of a vegetal world newly revealed—of a peak through a figurative keyhole, to spy on Nature at home, unveiling its carefully kept secrets—is rendered most powerfully by frequent and virtuosic uses of time-lapse photography. This footage updates familiar demonstrations of time-lapse's botanic revelations: scenes of

[3] Peter Tompkins and Christopher Bird, *The Secret Life of Plants* (New York: Harper & Row, 1973).
[4] Documentary scholars have long been sensitive to how epistephilia intertwines with questions of gender, difference, and power. See, for instance, Christian Hansen, Catherine Needham, and Bill Nichols, "Pornography, Ethnography, and the Discourses of Power," in Bill Nichols, *Representing Reality: Ideas and Concepts in Documentary* (Bloomington and Indianapolis: Indiana University Press, 1991), 201-228. On nature documentaries in particular, see Gregg Mitman, *Reel Nature: America's Romance with Wildlife on Film* (Cambridge, MA: Harvard University Press, 1999), and Laura U. Marks, "Animal Appetites, Animal Identifications" in *Touch: Sensory Theory and Multisensory Media* (Minneapolis and London: University of Minnesota Press, 2002), 23-39. And finally, perennially relevant to such questions is Laura Mulvey's "Visual Pleasure and Narrative Cinema," in *Film Theory & Criticism*, 7th ed., eds. Leo Braudy and Marshall Cohen (New York and Oxford: Oxford University Press, 2009; 1975), 711-722.

blossoming flowers and ripening fruits; leaves budding forth from rising stems; tendrils entwining, slime-molds dancing, contracting, then spreading. Some of the imagery goes beyond these conventional demonstrations, capturing patterns of growth, flourishing, and decay, not in the isolated theater of the laboratory, but (apparently) in the unbounded and uncontrolled wilds of the forest.

One sequence stands out for its graceful interweaving of synchronous phenomena (figure 1). Beginning with wide establishing shots of snow-capped firs, the film cuts to closer, ground-level views of the snow at their feet, its glistening white surface speckled with dust, twigs, and other debris. Within these closer framings, the scenery begins to shake subtly. The sunlight steadily pouring over it, the snow pack begins to contract and shrivel, deflating and collapsing on itself as jets of water trickle out. In a single time-lapse shot we finally see an inch or two of remaining snow shrink and evaporate, its liquid absorbed into the barren earth in an instant, at which point a few tentative buds creep up out of that same earth and begin to extend their arms in quivering, rapturous upward gestures. The effect plays out in an uncannily constant rhythm: ice melting into water, water absorbing into earth, and earth sprouting new buds as if each mutation were following the baton of some invisible conductor, in synch with the beat of Stevie Wonder's accompanying score—as if the transition from snow to dirt, and from dirt to plant, showed a continuous transformation of the same essential stuff.

This example is both cliché and extraordinary, continuing a long-running tradition of nature documentaries using time-lapse photography to visualize nature in new and exciting ways, literally *animating* and energizing nonhuman environments. Brief displays of growing plants even find their way into mainstream narrative films, as when a time-lapse shot of a

sprouting wheat germ (photographed by Ken Middleham, one of the cinematographers who contributed to *The Secret Life of Plants*) appears midway through Terrence Malick's *Days of Heaven* (1979). In her essay on "The Charge of the Real," Vivian Sobchack is struck by how this documentary insert, with its scientific gaze, fails to elicit in her an impression of excessive reality: "Why, when I know for certain it is real, does the wheat seedling in *Days of Heaven* germinate in a fictional and highly symbolic space?"[5] Sobchack reasons (and I would agree) that whereas the on-screen death of a real rabbit particularizes that being, and triggers our instinctive empathy, in ways that rupture a film's narrative containment strategies, the scene of a growing seedling is able to stand for more general, more textually assimilable referents. This individual seedling exemplifies the pattern of its species; it might be *any* seedling; and so it can symbolize abstract themes (the fecundity of nature, the continuity of becoming) in keeping with the story and aesthetics of Malick's film. And yet these familiar, fungible scenes of botanic growth do raise their own considerations about the nature of filmic realism and the character of our empathic involvement with on-screen nature. In the case of *The Secret Life of Plants*, how does this technically enhanced image of melting snow and emergent life illustrate, or argue on behalf of, the film's core thesis of panpsychism? How does this "special effect" contribute substantive claims about its subjects, and in what ways can it educate us about unknown aspects of our natural environment? Do we relate to such imagery as a record, or document, of physical reality—or, on the contrary, do we ingest it primarily as spectacle, a simulation or animation on a

[5] Vivian Sobchack, *Carnal Thoughts: Embodiment and Moving Image Culture* (Berkeley: University of California Press, 2004), 281.

continuum with other Hollywood visual effects? Do we even have clear criteria for distinguishing document and illusion in this sense?

Time-lapse effects, especially as a favored resource in science films and nature documentaries, have often aroused these sorts of questions about the relationship between their evident aesthetic power and their ambiguous epistemic value. After all, such questions sit at the basis of a great deal of film and photography theory. In the case of time-lapse photography especially, however, it seems that the *effect*, though far removed from the shock of unsimulated death, nevertheless depends on the viewer's conviction that what she sees is *real*—that the illusion, paradoxically, brings her senses *closer* to reality. Time-lapse effects are, then, entangled with the issue of film's realism, where realism is identified as an ontological attribute of the medium itself (its inherent connection with the real) and as a phenomenological effect—the medium's power to convey an *impression* of reality. Such questions have a long and contested history, from the formalist/realist divide in classical film theory, to the ideological critique sought by theorists in the 1970s and '80s, to more recent turns to embodiment, affect, and materialist aesthetics. In contemporary discourse, however, cinema's connection to reality is repeatedly staked to the notion of indexicality—a notion which is in many ways associated with digital convergence and the contested obsolescence of photochemical film. For many theorists today, the concept of the index explains a variety of tensions between analog and digital media. And yet theorizing the index often means returning to cinema's problematic roots in still photography, and to the classical assumption that film's ontology was tethered to photography's.

As *The Secret Life of Plants* makes clears, time-lapse photography has a peculiar relation to questions of realism, veracity, illusion, and knowledge—questions that are at once

classical and intensely modern. This chapter seeks to develop these questions as they pertain photographic media as a whole (including photographic cinema), with an eye to examining how they are inflected by the specificities of time-lapse. To begin, I explore what is at stake in contemporary debates concerning the fate of the index in the age of digital media, asking whether the currently dominant positions exhaust the power of film and photography to illuminate or explain one another. Looking beyond the problematics of "indexicality" theories, I urge a renewed and enriched appreciation for the notion of "affinities." This notion is especially noteworthy, and especially ambiguous, in Siegfried Kracauer's late *Theory of Film*, but it has deep and complex roots in romantic aesthetics, in early modern social theory, and in the rhetoric of other classical film theorists. While a discussion of affinities is unlikely to crystalize into a fully coherent or logically compelling *theory* per se, the word's colloquial, scientific, and literary genealogies make it appropriate—and appropriately messy—to thinking about the nature of photography, and about photography's connections to nature. I test how the resonances of "affinities" can help us reevaluate what it means for cinema to be *revelatory*, and end by unpacking the notion of "revelation" with reference to time-lapse photography. What, in the end, is time-lapse supposed to reveal to us, what secrets that we did not already know? The answer, I suggest, is not so much an unsuspected object or being, but new *qualities* of movement that, in turn, allow us to (re)imagine our connections to the organic world.

Film, Photography, and the Index

Cinema is increasingly a medium defined in relation to the digital. Granted, it has always been hard to draw any clear or stable boundaries around motion pictures—the

medium of film has always been a composite of evolving technologies, adapting the formal languages of traditional arts, and sustaining vital connections to various popular media and iconographies. But if cinema now, in the twenty-first century, belongs to a media ecology dominated by digital images, technologies, and infrastructures, it is also true that the movies are mostly digital things in themselves. They are shot on digital cameras, cut and composited on nonlinear editing applications, distributed as bits on physical hard drives (or else streamed over fiber-optic networks), and screened on digital projectors or high definition television sets. The scope and swiftness of the film industry's digital conversion has prompted political and economic concern from some, and introduced immediate and long-term uncertainties for archivists tasked with preserving these virtual objects.[6] It has also occasioned a theoretical crisis of identity, re-opening one of film theory's original questions: what, for the past century, has been the nature of the cinematic medium, and how does that nature delimit its aesthetic and rhetorical uses? If the materials and techniques grounding analog film are replaced by the cables, circuits, algorithms, and interfaces of digital computers, how substantially has film's ontology altered? Under the specter of obsolescence, and in response to these kinds of questions, the notion of indexicality has been given a great deal of attention.[7]

Recent literature on the fate of the index in the age of digital media is voluminous and variegated, but the broad concerns and fault lines in this discourse can be sketched in a brief survey. For new media theorist Lev Manovich, for instance, indexicality is a concept that

[6] On the archival question, see Giovanna Fossati, *From Grain to Pixel: The Archival Life of Film in Transition* (Amsterdam: Amsterdam University Press, 2011).
[7] The question of film's obsolescence was the theme for a panel convened by the art history journal *October* in 2002. See Malcolm Turvey, Ken Jacobs, Annette Michelson, Paul Arthur, Brian Frye, and Chrissie Iles, "Round Table: Obsolescence and American Avant-Garde Film," *October* 100 (2002): 115-132.

defines the difference between analog photography and digital imagery. He dubs cinema the "Art of the Index," stressing the way photochemical film imprints the visible surfaces of external reality, but cautioning that computer media redefine the nature of cinematic media, and that "what used to be cinema's defining characteristics are now just default options, with many others available."[8] Manovich outlines a perspective in which earlier, photographic cinema had been constrained in ways the traditional arts had never been before—obliged to reproduce the given appearances of real people, real places, and natural laws. Defying this matrix of analog limitations, though, the resources of computer-generated imagery radically liberate the art of filmmaking. The digital filmmaker can make and manipulate moving pictures that are faithful to her unfettered imagination rather than to existing physical facts, and thereby rediscovers the lost arts of precinematic, manual animation—she is even able to combine the freedoms of cartoon animation with the perceptual potency of photorealistic imagery. According to this outlook, digital cinema is "no longer an indexical media technology but, rather, a subgenre of painting."[9] Indexicality, then, describes that cord binding images in analog photographs to objects and places in the real world—that cord which digital media decisively sever for the sake of artistic empowerment.

Many of Manovich's more provocative conclusions have been disputed, yet his detractors often grant his core premises: that analog and digital cinema stand on opposite sides of an ontological divide; that this essential distinction has to do with the presence or absence of indexicality; and that analog and digital imaging technologies embody different internal logics. Where Manovich associates the logic of digital image-making with artistic

[8] Lev Manovich, *The Language of New Media* (Cambridge, MA.: The MIT Press, 2001), 293.
[9] Manovich, *The Language of New Media*, 295.

liberation, a return to painterly expression, others raise concerns about the political and cultural consequences implied by the demise of indexical media. Paul Willemen, for instance, points out that the spread of highly manipulable icons, which some might see as artistically liberating, also dovetails with authoritarian styles of governance in other spheres of life. For instance, new media's semblance of heightened interactivity is tellingly contradicted by its preferred mode of address: the second person declarative of the computer pop-up screen warning that "you have performed an illegal operation," which becomes "a way of addressing the reader/listener/viewer [or user] in a manner that brooks no challenge or dissent."[10] If, as theorists have long mused, our styles of thinking and interacting tend to mirror the discursive styles built into our dominant media, then the tendency of digital codes toward authoritarian interaction—following or executing a series of algorithmic commands—points to potentially troubling consequences. For Willemen, then, the loss of the index in photochemical film represents nothing less than a realignment of our regimes of communication, a paradigm shift signaling changes in the political climate, especially "the trend towards authoritarianism and advertising."[11] This argument fuses medium specificity claims to semiotic analysis and political critique, echoing the wide-ranging significance sought by earlier film theorists who saw cinema as an aspirational emblem for democratic, egalitarian political structures.[12]

In her own work on the fate of the index in digital cinema, Mary Ann Doane emphasizes the aesthetic problematics at stake, noting both the ambiguous future for digital

[10] Paul Willemen, "Reflections on Digital Imagery: Of Mice and Men," in *New Screen Media: Cinema/Art/Narrative*, eds. Martin Rieser and Andrea Zapp (London: BFI, 2002), 15.
[11] Willemen, "Reflections on Digital Imager," 15.
[12] Willemen invokes Sergei Eisenstein, but his association of indexical ontology with democratic political regimes recalls the realist theories of André Bazin and Siegfried Kracauer as well.

filmmakers, and the retrospective clarity given to analog film's material base. "[I]n the face of its imminent demise," Doane observes, "indexicality as a category has attained new centrality… One might go so far as to claim that indexicality has become today the primary indicator of cinematic specificity."[13] One register of the existential implications posed by the obsolescence of celluloid is seen in how contemporary experimental filmmakers have turned (or rather returned) to formalist-materialist concerns in their work—e.g., by foregrounding the palpable attributes of photochemical stock, or by manually marking, reworking, or disfiguring that material in dramatic ways.[14] In these works, indexicality becomes essential to art, capturing both the way film is imprinted by rays of light and the way human hands leave intended and unintended signatures. Inverting Manovich's equation of digital manipulation with a return to the liberties of pre-photographic artistic media, Doane provocatively questions whether digital media can function as media at all. Media of art are, she points out, normally conceived in terms of a dialectic of possibilities and limitations, powers and resistances, which are themselves bound up with questions of materiality and immateriality.[15] Digital media, by contrast, seem to deny any semblance of material resistance whatsoever. If nothing else, it is unclear how we might specify the digital's "enabling impediments," and while digital technologies are obviously made up of physical materials subject to natural laws (those of silicon and fiber optics, for starters), those materials and laws are never legibly manifest in the images themselves—they are never

[13] Mary Ann Doane, "The Indexical and the Concept of Medium Specificity," *differences: A Journal of Feminist Cultural Studies* 18, no. 1 (2007), 129.
[14] Tess Takahashi, "After the Death of Film: Writing the Natural World in the Digital Age," *Visible Language* 42, no. 1 (2008): 44-69.
[15] "The potential of a medium would thus lie in the notion of material resistances or even of matter/materiality itself as, somewhat paradoxically, an *enabling impediment*. The juxtaposition of negativity and productivity is crucial here. A medium is a medium by virtue of both its positive qualities (the visibility, color, texture of paint, for instance) and its limitations, gaps, incompletions (the flatness of the canvas, the finite enclosure insured by the frame)." Doane, "The Indexical and the Concept of Medium Specificity," 130.

indexed, as it were, at the level of the graphical interface. As Doane puts it, "the relation of digital representations to their material conditions of existence (which does exist) is so abstract as to be almost unattainable."[16]

While Manovich, Willemen, and Doane exemplify different outlooks and priorities in discussing cinema's transition from analog to digital, they basically agree that this transition hinges on the question of indexicality—specifically, that digital images are not indexical in the way that analog film once was. Several scholars have entered this debate from a different angle, challenging the premise that digital images are any less "indexical" than photochemical ones. Typically by recalling us to the specificity of computer hardware and the physical imprints that ground even the most virtual imagery, or else they return to the letter of Peirce's original texts on semiotics. Laura U. Marks, in her article "How Electrons Remember," argues that with digital media there is no actual loss of materiality, hence no meaningful rupture with analog indexicality. Rather, digital media challenge us to locate their material traces differently. She gestures toward a complex notion of "quantum indexicality" that operates at the invisible level of electrons—a notion that blends C.S. Peirce's semiotic theories with advanced concepts in theoretical physics. Citing David Bohm, Niels Bohr, and Einstein's account of "spooky action at a distance," she stresses "the ability of subatomic particles to communicate along traceable pathways," and thereby preserve imprints and traces just as surely as photographic grain does. Such an argument asks that we bring our concepts of "materiality" up to date with physical research on the subatomic bodies that underwrite our phenomenal universe. Martin Lefebvre, meanwhile, addresses the question of digital indices not by stressing the obscure behavior of quarks and

[16] Doane, "The Indexical and the Concept of Medium Specificity," 143.

quanta, but by delving into the arcane minutiae of Peirce's pragmatist philosophy. Peirce's semiotic system, Lefebvre points out, is concerned less with ontology (what the world is in itself) than with knowledge—how our knowledge about the world is formed and communicated. And while indexical signs combine with icons and symbols to communicate new information, they *always* operate by appealing to a background of pre-installed knowledge and beliefs—what Peirce called "collateral knowledge."[17] Lefebvre finds that photographs and CGI may differ profoundly in their underlying technologies and relevant methodologies, but these two kinds of images are equally indexical because they both require their own "semiotic supplements [and] collateral knowledge in order to be interpreted as factual signs."[18] In other words, their significance requires that we recognize what they are and that we are already familiar with how such images are generally made and manipulated. Neither one is more materially rooted than the other; neither one is more reliable as evidence. But they do involve different kinds of knowledge and practical experience in establishing truth claims.

The above authors exemplify different conceptions and attitudes regarding indexicality, taking it as an ontological category (the way different media are materially marked by physical surfaces) or as a semiotic label, as a constraint or as a condition of creative expression, as a principle that fades with the emergence of digital code, or else as a quality that persists across technological thresholds. What is consistent within this field of opinions on the index, however, is the confidence that indexicality is a uniquely *useful* concept in helping us understand the relation between analog and digital communication.

[17] Martin Lefebvre, "The Art of Pointing: On Peirce, Indexicality, and Photographic Images," in James Elkins, ed., *Photography Theory* (New York: Routledge, 2007), 235.
[18] Lefebvre, "The Art of Pointing," 242.

Even Manovich, who welcomes the end of analog photography and the redemption of manual animation, gives great importance to the index at a metatheoretic level. The concept is decisive in demarcating photography from animation, analog from digital, old from new media. For Tom Gunning, however, all of this commotion about the index encapsulates the confusions and blockages that plague contemporary film theory.[19] Film theorists, he points out, tend to identify the index with a small set of physical traces—fingerprints, footprints, death masks, stains, scars—neglecting some of the more interesting cases (arrows and captions, verbal shifters, loud noises that fix our attention) that Peirce originally offered. These latter cases in some sense point, but they do so without being the sorts of evidentiary marks that evoke the mystique of the photograph. The intellectual cost of this limited approach is twofold. For one thing, as Peirce specialists have rightly pointed out, in the vernacular of film studies the idea of indexicality has been imagined and applied far too constrictively, exploiting only a partial sample of the term's possible meanings.[20] On the other hand, contemporary theory's fixation on the index has led to a kind of intellectual fixity, neglecting to explore other possible pathways into the nature of cinematic realism. In its current theoretical guise, Gunning argues, the idea of the index encourages us to obsess over the invisible bonds between image and reality, and to dispute whether and how they are dissolved by digital media. If, on the other hand, we challenge ourselves to think about the index as more than a trace or mold, we can effectively reopen the "classical issues of film

[19] "The nonsense that has been generated specifically about the indexicality of digital media (which, due to its digital nature, has been claimed to be nonindexical—as if the indexical and the analog were somehow identical) reveals something of the poverty of this approach." Tom Gunning, "Moving Away from the Index: Cinema and the Impression of Reality," *differences: A Journal of Feminist Cultural Studies* 18, no. 1 (2007), 31.
[20] Gunning, "Moving Away from the Index," 30.

theory" in light of recent technological developments, and in ways that avoid the pitfalls of essentialism and classicism.[21]

Gunning points out that debates about indexicality are, at root, contests over cinematic realism—inquiries into the nature and implications of cinema's so-called "impression of reality." His own theoretical gambit is that these questions are more interesting and more timely if we stop fretting about indexicality and think more deeply about the phenomenon of *movement* itself, and how definitively this quality belongs to *the movies*. His impatience with the notion of the index centers on the term tends to connote a sort of fixity or stasis. Discussions of indexical realism tend to trope cinema as just one thing at any given time (rather than an unstable composite of media elements), imprinting the world at one moment and then another, forging a stable correspondence between a world gone by and its corresponding record on the film strip. This approach takes the realism of film as parasitic upon that of photography, as a series of indexical, reality-imprinting snapshots streaming by at twenty-four frames per second. It misses both the promiscuity of the medium in question and the *present*-ness of its realist effects—its power to involve our empathic and physical participation in its moving displays. The *movements* we see, Gunning seems to suggest, can be referential in just the way photographs are supposed to be, and if we give primacy to cinema's movement (as opposed to its photographic imagery), we give renewed importance to its phenomenological realism: "We do not just *see* motion and we are not simply affected emotionally by its role within a plot; we *feel* it in our guts or throughout our bodies."[22] Our visceral and empathic response to film's layered machinations of

[21] Gunning, "Moving Away from the Index," 34.
[22] Gunning, "Moving Away from the Index," 39.

movement, in other words, index our affirmation and participation in the reality of what we behold. We ratify the reality of the movements we behold, as it were, with the stirrings of our own bodies.

If, as Gunning argues, the current state of indexical film theory represents a perverse confusion, it is all the more important to recall some of the historical roots of this confusion, especially how the concept bridges the concerns of different generations of theorists in revealing ways. The term's importance in Anglophone film studies is generally attributed to Peter Wollen's 1969 *Signs and Meaning in the Cinema*. In a chapter that reappraises Bazin's realist theory of photography and film, Wollen suggests that the former's seemingly mystical ontology conforms in its main contours to Peirce's category of indexical signs.[23] "Time and again," writes Wollen, "Bazin speaks of photography in terms of a mould, a death-mask, a Veronica, the Holy Should of Turin, a relic, an imprint," all of which stress "the existential bond between sign and object which, for Peirce, was the determining characteristic of the indexical sign."[24] While Wollen acknowledges the "curious admixture of Catholicism and Existentialism which had formed Bazin," his reading nevertheless translates Bazin's ontology into an account of indexical semiosis—a "curious admixture," we might say, of Peirce and Bazin.[25]

As appealing as Wollen's comparison feels at first blush, recent commentators have pointed out how this reading performs a kind of shotgun wedding between Bazin and Peirce, dismissing profound incompatibilities in their respective priorities and patterns of thought.

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[23] Peter Wollen, "The Semiology of the Cinema," in *Signs and Meaning in the Cinema*, 3rd ed. (Bloomington: Indiana University Press, 1972), 116-154.
[24] Wollen, "Semiology of the Cinema," 125-6.
[25] Wollen, "Semiology of the Cinema," 131.

Peirce's semiotics gives more systematic sense to Bazin's central analogies, but according to Daniel Morgan it misses the core of Bazin's argument—the sense of existential transfer between world and photographic image, which shades into a "formulation of ontological 'identity' or 'equivalence' to describe the relation between object and image."[26] Such an equivalence is bound to strike us as "uncomfortably strange," but it is central to what distinguishes an ontology of photographic images from an analysis of photographic signs.[27] Acknowledging what is problematic in his reading of Bazin, I would nevertheless suggest that Wollen's essay remains an important encounter between classical and modern film theory. It represents a critique and repudiation of an earlier school of thought—an Oedipal slaying that has, of course, since been repeated in recent critiques of 1970s film theory—but it also marks a zone of shared concern. By linking Bazin's "Ontology" to notions of indexicality, his realist aesthetics could participate in an ongoing debate regarding what kind of signifying system the cinema might be. Wollen recognized Bazin as an interlocutor in a conversation that involved himself, Stephen Heath, Christian Metz, and later, Laura Mulvey and the flowering of Marxist, feminist, and Lacanian film theories. Here, at the metatheoretic level, "the index" signifies, not a rupture between old media and new, but a continuity of conversation. It captures the (negative) relevance of classical realism to the field of semiotic, psychoanalytic, and ideological criticism.

1970s film theory has been subjected to an often merciless critique over the last two or three decades, and that critique has gone hand in hand with much-needed reappraisals of Bazin, Siegfried Kracauer, and other classical realists. Even as Bazin and company have

[26] Daniel Morgan, "Rethinking Bazin: Ontology and Realist Aesthetics," *Critical Inquiry* 32, no. 3 (2006), 449.
[27] Morgan, "Rethinking Bazin," 450.

garnered new appreciation, however, Wollen's indexical label seems to have stuck. It is commonplace to speak of "Bazinian realism" and "indexical realism" as though the two categories were interchangeable. The constellation of political and spiritual values that Bazin saw embodied in filmic records is thereby conflated with a legalistic discourse about authenticity, testimony, and reliable chain of custody. The self-sufficient category of "being" is, accordingly, confused with discursive constructions of "evidence." Likewise the term "indexical" is often treated as a short-hand for purely material connections—for noumenal reality, existential states that persist independent of our perceptions—which distorts its original definition as a category of *signs*. At its most productive, the concept of the index helps us describe the connections between the mental and the material, how we form concepts and communicate about our socially shared environment. As a pragmatic concept, though, the physical world it collaborates in describing is always provisional, and unthinkable apart from our practical ways of acting in it and conversing about it. For the most part, then, what is called into question in the discourse about digital indexicality is neither Bazin's ontology nor Peirce's index, but the hybrid category that film theorists have made out of them. If that category seems to be in doubt now, perhaps this is in part due to the contradictory spirit in which it was conceived.

Acknowledging these contradictions, it makes sense that scholars have returned to the dual sources of this mongrel concept, granting Bazin and Peirce a divorce that allows the nuance complexity of each to stand in relief. In urging us to "move away from the index," Gunning, like Manovich, proposes that we dwell less on cinema's disputed relation to photography, and instead ground our analysis in the phenomenon of animation. If we are to arrive at a "contemporary theory of cinematic realism," we will need to ask, in the context of

digital technologies and paradigms: "what are the bonds that cinema forges with the world it portrays? Are these limited to film's relation to photography? Is the photographic process the only aspect of cinema that can be thought of as indexical, especially if we think about the term more broadly than just a trace or impression?"[28] In effect, he brackets our interest in molds and traces and other static analogs of photographic imprinting, and asks what is left to say about cinema's realism—its indexicality, its visceral appeal, its referential relation to the world—if we think more deeply about the ways in which movies *move*. By the same token, though, we can outline different applications for the index, and different ways for photography and cinema to illuminate each other *besides* the index. How can our account of photography be dynamized in its own right, and how might the model of photographic media help us articulate the claims that other kinds of moving images make upon the real?

Affinities

In thinking through the nature and significance of time-lapse's spectacularizing of nature—the effect's encoding and transformation of real, worldly phenomena—I am struck by the potential usefulness both of the concept of indexicality *and* of photography theory more broadly. I am equally interested in how the example of time-lapse photography might open a new perspective on traditional theories of cinematic realism. In identifying other ways to develop the pertinence of photography to this effort, one pathway branches out of the concept of indexicality itself. Close readings of Peirce remind us that the index concerns

[28] Gunning, "Moving Away from the Index," 34. This passage reflects some ambivalence in Gunning's argument. Having contended that the very concept of the index has held film theory back, he nevertheless gestures toward the ways in which animation (like photography, and contra Manovich) meets the criteria of the Peircean index—as though the index might, after all, be important in theorizing animation's impression of reality.

existential connections. More precisely, it concerns how immaterial things (like our words, concepts, ideas: in a word, our *meanings*) are linked to the material world. The triad of symbol, icon, and index is meant to classify signs and the networks along which they function, and the three terms are necessarily interdependent. Our signs are indexical at those points where they touch objective reality, but in order to be significant as such, they always depend upon the other classes of signs and upon our more or less intricate collateral knowledge. As signs which dramatically combine iconic and indexical functions, photographs evoke material connections (that sense of "*having-been-there*" to which Barthes attests) because we *know* how they are normally formed.[29] We have direct or second-hand experience with the equipment; we are reasonably familiar with how the resulting images invite or resist manipulation. We know that we "press the button," while it "does the rest," and this mechanical, streamlined causal relation certifies the resulting image's authenticity.[30] We may dispute the *truth* of the resulting likeness, its impression of a face, a space, or a movement. But for most of the nineteenth and twentieth centuries, only in exceptional circumstances would one contest the *fact* of what the photograph portrays. As Lefebvre points out, this authenticating function is common to indexicality in the context of other media, and so cannot really specify photography or film.[31] What *is* specific to photographic

[29] Roland Barthes, "Rhetoric of the Image," *Image/Music/Text*, ed. and trans. Stephen Heath (New York: Hill and Wang, 1978), 44. "The type of consciousness the photograph involves is indeed truly unprecedented, since it establishes not a consciousness of the *being-there* of the thing (which any copy could provoke) but an awareness of its *having-been-there*… [I]n every photograph there is the always stupefying evidence of *this is how it was*, giving us, by a precious miracle, a reality from which we are sheltered."

[30] "You press the button, we do the rest," is the well-known slogan for Kodak cameras, purportedly coined by George Eastman in 1888.

[31] Lefebvre, "The Art of Pointing": "The difference between a painting and a photograph lies in the way painting can achieve dicent status" (244)—that is, "they do not require the same semiotic supplements or the same collateral knowledge in order to be interpreted as factual signs" (242).

media, though, are the automatisms upon which their indexical significance depends: the automatic, technological, authorless forces that produce a photograph's vivid likenesses.

Automatism and indexicality are tightly linked concepts. Both concern material connections and forces of physical causation, especially nonhuman causation. Even when indices derive from intentional acts and gestures—the pointing finger, the artist's signature—its specific force applies independently of subjective intentions, automatically and autonomously. Automatism would seem to be a crucial component in the operation of indexical signs: it directs how we recognize and respond to those aspects of a sign that function on their own. For some critics, indexicality and automatism are only different words for the same thing, addressing the same materialist questions from slightly different angles.[32] Despite the surface resemblance of these two concepts, however, they belong to different histories, suggest different exemplars, and have different final significance. The index involves physical forces, traces, and connections, but is ultimately concerned with human knowledge: how mental phenomena are bridged to material things. Automatism, by contrast, addresses phenomena that are radically independent of conscious life, even as they uncannily parody it. It is an idea embodied in wind-up dolls, mechanical apparati, and music boxes; it evokes unconscious behavior, somatic memory, automatic writing and drawing, and various chance-based procedures in modernist art practice. Automatism, then, indicates a rich and complex area for theoretical exploration, both in conceptualizing the workings of photographic media and in understanding the praxis and phenomenology of time-lapse

[32] Walter Benn Michaels, "Photographs and Fossils," in *Photography Theory*, 436.

techniques. For now, I will defer a fuller consideration of automatism until the third chapter of this dissertation.

Another alternative to the perplexities of the index is to consider photography and animation, stillness and movement, not as mutually exclusive categories but as complementary terms that dialectically define the medium of cinema. Garrett Stewart has taken this approach in two recent books—*Framed Time* and *Between Film and Screen*—as has Tom Gunning in his essay "Animating the Instant: The Secret Symmetry between Animation and Photography."[33] Especially germane to this perspective is the collection *Still/Moving: Between Cinema and Photography*, edited by Karen Beckman and Jean Ma, which addresses the "essential hybridity and interconnectedness" of photography and cinema, and how this "present[s] a challenge to homogeneous and reductive notions of medium specificity and open[s] an important site of overlap between art history and cinema studies."[34] This emergent interest in the interface between stillness and motion is in important respects indebted to the film philosophy of Gilles Deleuze, particularly his invocation, via Bergson, of duration and vitalism. But where Deleuze focuses on narrative cinema's stylistic evolution from primitive *images-that-move* to mature *movement-images*, and from *movement-images* to *time-images*, Beckman and Ma ground their collaboration in the "affinities and tensions that exist between cinema and photography."[35] Characterizing the relation between photography and cinema in terms of "affinities" (and tensions) is a

[33] Garrett Stewart, *Between Film and Screen: Modernism's Photo Synthesis* (Chicago and London: University of Chicago Press, 1999); and *Framed Time: Toward a Postfilmic Cinema* (Chicago and London: University of Chicago Press, 2007). Tom Gunning, "Animating the Instant: The Secret Symmetry between Animation and Photography," in *Animating Film Theory*, ed. Karen Beckman (Durham and London: Duke University Press, 2014), 37-53.
[34] Karen Beckman and Jean Ma, eds., *Still/Moving: Between Cinema and Photography* (Durham and London: Duke University Press, 2008), 3.
[35] Beckman and Ma, "Introduction," *Still/Moving*, 17.

welcome alternative to the idea that the one medium simply absorbs the other, or that their association begins and ends with indexicality. But where exactly these affinities obtain, and what theoretical significance might they, themselves, have? Can the vague notion of "affinities" in fact be made to do serious theoretical work?

The term's history and rhetorical value in theories of film and photography is ambiguous, but suggestive. The Oxford English Dictionary gives a wide range of possible meanings and etymologies for "affinity," all of them "relating to connection, and to the forming of connections."[36] These connections may be voluntary, as in a union by marriage, and based on inherent attractions; they may be genetic, as with kinship; they may be spiritual, as in the bond between godchild and godparent (a connection formed, in Catholic theology, through the ritual of baptism). Affinities may also express structural resemblances between languages, species, individuals, or chemical compounds—or they may denote proximity (in space, or time, or essence) moreso than a connection per se. Finally, these variant senses apply to highly diverse contexts: to social, religious, and legal bonds between human beings; to the realms of plants and animals; to atoms and molecules; to languages and to mathematics. In most cases, though, the term's significance involves several of the above senses simultaneously, and invites metaphoric slippage between empirical and empathic connotations. For instance, an affinity in the sense of physical resemblance may in fact attest to affinity in the sense of common ancestry (first cousins look alike because they share two grandparents); and one may speak with equal naturalness of a "magnetic pull" between two lovers, or of an "inward sympathy" between two chemical compounds. Thus, while early

[36] *Oxford English Dictionary Online*, s.v. "affinity," accessed November 25, 2016, http://www.oed.com.proxy.library.ucsb.edu:2048/view/Entry/3417

usage of the word was usually to qualify social unions (especially marriages, alliances, and resulting kinship networks), its most dominant by the turn of the nineteenth century was with the emergent science of chemistry—in the form of the empirical study of *chemical affinities*, which aimed to describe, systematically and exhaustively, the observed attractions and repulsions, reactions and interactions, of all known chemical compounds.[37]

While there is little discussion, in theories of film and photography, that addresses the notion of affinities head-on, their importance is operative in the allusive, analogical, and often vague style of inquiry that characterizes many canonical texts. This is especially true of those arguments which consider a range of *a posteriori* comparisons, synthesizing these into general conclusions about the medium as such, as opposed to conducting an *a priori* analysis of the medium's presumed properties. Numerous film theories seem to deduce their conclusions from attributes that later prove to be critically incomplete or historically contingent—postulating, for example that film is an outgrowth of photography; that it is silent; that it renders the world in black and white. When these technical features turn out to be temporary components after all, any aesthetic theory committed to them would seem to be compromised. But at least as often, early thought about film advanced through external comparisons to other media, or by remarking those subjects which seemed (on intuitive, aesthetic lines) to make the most satisfying subjects for the medium. Bazin's "Ontology" essay, for instance, seeks the essence of the photographic medium by considering its relation to the older graphic arts, and how they each mirrored or even spiritually embodied ancient funerary rites and artifacts—mummies, death masks, shrouds—in magically resisting the

[37] This approach was dominant through most of the nineteenth century, and gradually gave way to atomic theory and Dmitri Mendeleev's periodic table of elements. See Trevor H. Levere, *Transforming Matter: A History of Chemistry from Alchemy to the Buckyball* (Baltimore and London: The Johns Hopkins University Press, 2001).

unidirectional flow of time. In his critical writings, Bazin works out his realist aesthetics through his tributes to science films, animal performances, and documented risks—subjects with which the medium seemed to demonstrate a natural rapport.[38] Similarly, when Béla Balázs grandly speculates into the rediscovered language of phsyiognomics, he grounds these dreams in the seemingly self-evident attraction of the cinematic image for human faces and covert gestures.[39] Or consider how Jean Epstein's notoriously obscure notion of *photogénie*, which designates "any aspect of things, beings, or souls whose moral character is enhanced by filmic reproduction," can be taken as a declaration of affinities.[40] *Photogénie* is not like Eisensteinian montage—it is not an inscription of authorial will upon the medium, it is not an independent production of the medium itself. Rather, it names a chance find (gleaned by aesthetic intuition), a discovery of something preexisting in reality, which then reacts spontaneously and ecstatically with the medium in the process of capture and projection. Through such photogenic interactions, cinema discovers its own spiritual companions, and, by delineating them, we sharpen our understanding of the medium itself.

Among classical film theorists, though, the term "affinities" is most explicit, and most significant, in Siegfried Kracauer's late *Theory of Film*. Kracauer prefaces this work with the guiding assumption that "film is essentially an extension of photography and therefore shares with this medium a marked affinity for the visible world around us"[41]—an assumption which

[38] Bazin's attraction to these subjects is typified by: "Cinema and Exploration," *What is Cinema?*, 1:154-163; "Science Film: Accidental Beauty" in *Science is Fiction: The Films of Jean Painlevé*, ed. Andy Masaki and Marina McDougal with Brigitte Berg, trans. Jeanine Herman (Cambridge, Mass.: The MIT Press, 2000), 144-7; and "Death Every Afternoon," in *Rites of Realism: Essays on Corporeal Cinema*, ed. Ivone Margulies, trans. Mark A. Cohen (Durham and London: Duke University Press, 2003), 27-31.
[39] *Béla Balázs: Early Film Theory; Visible Man and the Spirit of Film*, ed. Erica Carter and Rodney Livingstone (New York: Berghahn Books, 2010).
[40] Jean Epstein, "On Certain Characteristics of *Photogénie*," in *French Theory and Criticism, I*, ed. Richard Abel (Princeton, NJ: Princeton University Press, 1988), 314.
[41] Siegfried Kracauer, *Theory of Film: The Redemption of Physical Reality* (Oxford and New York: Oxford University Press, 1960), ix.

he elaborates in two subsequent sections. To begin with, in his introductory section on photography, he enumerates that medium's "inherent affinities"—phenomena for which the camera has a demonstrable attraction, things or qualities it even seems to *want* to portray because it is so naturally suited to them. He groups these phenomena into four broad categories: "unstaged reality," "the fortuitous," "endlessness," and "the indeterminate."[42] Having laid out the still camera's affection for these qualities, Kracauer submits that motion picture photography inherits these (being an extension of still photography) plus one more: cinema, he says, has an affinity for "the flow of life."[43] A handful of scholars have returned to Kracauer's discussion of affinities to explore how they prefigure the themes and investments of contemporary, digital cinema.[44] More often, however, this moment in Kracauer's theory is taken as symptomatic of his preoccupation with outmoded medium specificity claims.[45] Kracauer's commitment to delineating cinema's natural capacities is clear: he speaks repeatedly of its "essential ingredients," "peculiar properties," and "distinguishing features," echoing the rhetoric of Clement Greenberg (with whom he had been in conversation during the writing of *Theory of Film*).[46] But it is less obvious what

[42] Kracauer, *Theory of Film*, 18-23.
[43] Kracauer, *Theory of Film*, 60-74.
[44] Thomas Elsaesser, "Siegfried Kracauer's Affinities," *NECSUS. European Journal of Media Studies* 3, no. 1 (2014): 5-20.
[45] Though she vigorously defends Kracauer from charges that he is a "naïve realist," and argues that his ontological rhetoric disguises a theory that was ultimately one of cinematic *experience* (and which is more explicit in his earlier notebooks), Miriam Hansen includes the discussion of affinities as part of the critic's semi-conscious "repression" of his more complex and historically-engaged ideas. "[In the *Theory of Film*,] the specifically modern and modernist moment of film and cinema is transmuted into medium-specific affinities with visible, physical, or external reality." Miriam Bratu Hansen, *Cinema and Experience: Siegfried Kracauer, Walter Benjamin, and Theodor W. Adorno* (Berkeley and Los Angeles: University of California Press, 2012), 256.
[46] Kracauer, *Theory of Film*, vii, viii. On Kracauer's association with Greenberg and the "loose-knit" New York intellectual scene, see Johannes von Moltke, *The Curious Humanist: Siegfried Kracauer in America* (Oakland: University of California Press, 2016), 35-38 and passim.

Kracauer means by "affinities," how this term became such a persistent theme in his text, and how a taxonomy of perceived affinities is supposed to inform us about film's ontology.

Kracauer tends to characterize affinities as though they were objective attributes. In the chapter on photography, he juxtaposes the medium's inherent affinities with, one the one hand, the artistic agency exercised through "the photographic approach," and with the wholly subjective aspects of "photographic reception" on the other. Photography's affinities register its attunement to things in their radical indifference to human meaning, "nature as it exists independently of us."[47] The medium cannot accommodate the aesthetics of traditional tragedy, in which each object assumes its proper role in relation to some purely human drama, and instead projects a heretofore hidden life onto the solitary being of the objects themselves. This objective level of being is nevertheless disclosed to us in moments of sublime appreciation: we know these phenomena to be "inherently photographic" because they "strike us" so.[48] Ontology and psychology are therefore put in tension: Kracauer speaks of *objective* tendencies, but he finds these tendencies only through the free play of critical faculties, apparently unguided by any specifiable and deterministic criteria. His theory of film is not, in other words, an aesthetics deduced from a stable ontology, but an ontology derived from aesthetic intuition and sensitivity.

This dynamic of aesthetics and ontology clarifies the often misunderstood thrust of Kracauer's realism. Far from a "naïve realism" in which a world of solid facts is faithfully transcribed by photographic media, Kracauer offers a theory of reality *as constituted by film and photography*, and as therefore available to social reformation. Film's power, for

[47] Kracauer, *Theory of Film*. 18.
[48] Kracauer, *Theory of Film*, 18.

Kracauer, lies precisely in undermining ordinary perception and remaking our historical moment; it is a medium "capable of advancing and registering disintegration in a material, sensorily graspable form, of archiving the disintegrated particles, and of reconfiguring them toward a different, as yet unknowable order."[49] The inherent affinities vivify how the photograph, as a picture of its object and as an emblem for our own reformed perception, *interprets* reality, qualifies it in potentially radical ways. Its aesthetically resonant tendencies teach us that reality is never eternal, stable, and conceptually containable (as it may appear to be in other fictions and according to other philosophies). Instead, reality—that is, photographic reality—is contingent, variable, evolving, unbounded, indeterminate, and subject to chance moreso than to law.

While Kracauer nowhere offers an explicit theorization of the concept of affinities, we can give the term greater depth by examining how it recalls two indispensable German intellectual precedents—Johann Wolfgang von Goethe and Max Weber. Goethe's 1809 novel *Elective Affinities (Die Wahlverwandtschaften)* takes its title from the science of chemistry, projecting this discipline's into a thematic framework for the human drama that will unfold—a story of erotic entanglements, infidelity, and the fatal contradiction of social law and carnal desire.[50] Eduard and Charlotte begin the fiction as a happily married aristocratic couple, their union based in mutual love, each partner having terminated a previous marriage of mere social convenience. The couple is visited for a time by two more characters—Eduard's friend "the Captain," and Charlotte's niece, Ottilie—with whom Charlotte and Eduard, respectively, soon find themselves infatuated. The remainder of the

[49] Hansen, *Cinema and Experience*, 256.
[50] Johan Wolfgang von Goethe, *Elective Affinities*, trans. David Constantine (Oxford, UK: Oxford University Press, 1994).

narrative relates the frustrated attempts of the four characters to recouple according these erotic attractions: Charlotte with the Captain and Eduard with Ottilie. Eduard and Charlotte have a child together, who uncannily resembles both the Captain and Ottilie (the married couple's psychic attachments superseding genetics in determining the child's outward form), and who is doomed to a tragically brief life. Ottilie is struck with grief and convinced of her complicity in the child's death, and so renounces Eduard and falls fatally ill herself. The novel ends with both Ottilie and Eduard dead, their love yet unfulfilled; but, in an image of ambiguous solace, they are buried alongside one another at Eduard's estate.

The chemical inspiration for the story is foregrounded in an early scene, in which the Captain (a dabbler in science) explains the theory of elective affinities for the foursome. Put most simply, the doctrine of affinities states that, in chemistry as in social affairs, like is drawn to like while incompatible elements repel one another. But these interrelationships will also

> vary according to the different natures of things concerned… We say of those natures which on meeting speedily connect and inter-react that they have an affinity for one another. The affinity may be very remarkable. Alkalis and acids, although opposed to one another and perhaps precisely because they are so opposed, will in a most decisive way seek out, take hold of, and modify one another and form, in so doing, a new substance together. We have only to think of lime, which manifests towards all acids a strong inclination, a decided wish for union.[51]

This potentially odd detour into chemical theory prefigures the human drama which is beginning to unfold. Just as molecules of limestone will, in the presence of certain reagents, reorganize themselves into new compounds, so the legal and spiritual bond between Eduard and Charlotte is corroded by the presence of the Captain and Ottilie, driving them to make a new combination. Just as chemical theory metaphorically explains the vicissitudes of human attraction, the Captain's account also anthropomorphizes chemistry from the outset. He

[51] Goethe, *Elective Affinities*, 31, 32.

portrays acids and alkalis as "seeking out" and "taking hold of" one another, while limestone manifests its own "strong inclination."[52] His phrasing endows inert, minute materials with individual personalities, desires, tendencies, their own personal feelings of attraction or repulsion, and the power to "elect" their corresponding mates.

Goethe's fictional exploration of the "chemistry of social relations"[53] is neither a reduction of social dynamics to chemical-material determinants, nor an idealist vision of material bodies bent to human wills. Neither mind nor matter can claim priority in this extended metaphor. Instead, as in so much of the poet-naturalist's thought, he uses the form of the novel to sketch a non-deterministic correspondence of the physical and social worlds, a mysterious symmetry that gives moral significance to natural phenomena and casts ethical tensions and social mores in an alien, clarifying light.[54] "Affinities," in this case, expresses not only the play of resemblances, attractions, and interactions within each of these worlds, but also the mimetic correspondence across them; it expresses the connection, as resemblance and interpenetration, of the material and the spiritual.

The other precedent that plausibly informs Kracauer's stress on affinities was published nearly a century after *Elective Affinities*, reviving the poet's evocative terminology for the sake of sociological theory. Max Weber's 1904 essay, "The Protestant Ethic and the Spirit of Capitalism," remains a foundational text in the social sciences, and is often

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[52] This anthropomorphic tendency is even more explicit in other passages, which picture chemical reactants as either "friends and old acquaintances" or else as "strangers"; as "blood relations" or else as "related in spirit and in the soul." Goethe, *Elective Affinities*, 31-2.

[53] Andrew M. McKinnon, "Elective Affinities of the Protestant Ethic: Weber and the Chemistry of Capitalism," *Sociological Theory* 28, no. 1 (2010), 112.

[54] It is worth asking how far this is true in contemporary thought. English idiom maintains various metaphoric links between social and chemical interaction—instances in which individuals find they have "good chemistry" or "team chemistry," etc.. On the other hand, advances in neuroscience seem to encourage a casual reductionism, in which emotions, desires, and the psychic life more broadly, are assumed to be subjective symptoms produced by underlying, and independently determined, chemical reactions.

juxtaposed with Karl Marx's historical materialism. Where Marx's system is taken as mechanistic—the system of production forms society's base; religious, philosophical, and artistic creations make up the superstructure that is predictably projected by that base—Weber offered a more ambiguous account of how the economic fact of capitalism was anticipated, reflected, and in some sense catalyzed by corresponding movements in the religious sphere, particularly in the Calvinist communities of North America and Northern Europe. To Articulate this line of mutual formation—the non-mechanistic manner in which protestant mores and capitalist sentiments encountered and influenced one another—Weber needed a conceptual alternative to the mathematical, deterministic paradigm of architecture and engineering that Marx had previously instituted. This is the spirit in which he resurrected Goethe's organic, chemical model of social interaction, envisioning not of the grinding wheels of historical dialectics, but the liquid dynamics of *Wahlverwandtschaften*—the "elective affinity of ethical prophecy and monotheism," and "those *elective affinities* of the bourgeoisie with certain styles of life."[55] This alternative metaphor informed Weber's description of how "religious influences *have in fact* been partially responsible for the qualitative shaping and the quantitative expansion of [the 'spirit' of capitalism] across the world, and [how] concrete aspects of capitalist culture originate from them."[56] Weber's notion of "affinities" describes real forces of influence, articulation, accommodation, and formation between the religious and economic spheres—but it is crucial that these forces are never necessary nor sufficient. Protestant value systems do not always lead to the adoption of capitalism, nor does capitalism always need the preparatory influence of Calvinism before

[55] Andrew M. McKinnon, "Elective Affinities," 110.
[56] Max Weber, *The Protestant Ethic and the "Spirit" of Capitalism and Other Writings*, trans. P. Baehr and G.C. Wells (New York: Penguin, 2002), 36. Quoted in McKinnon, "Elective Affinities," 120.

it can take root. Rather, the peculiar shape and explosive spread of capitalism in the West was, Weber contended, the result of the amplifying confluence of these two historical forces.

It is important that neither Goethe's nor Weber's invocation of affinities is meant to refute materialism per se. In fact, both arguments charge us with reexamining what we mean by "material" in the first place. To this extent, they deepen our appreciation of the "material aesthetics" that Kracauer's theory of film intends to promote. In my view, Kracauer could hardly have been unaware of the legacy of the word "affinities" in the works of these two earlier giants of German thought.[57] But regardless of whether he was consciously channeling their influence, Kracauer's deployment of affinities in important respects mirrors Goethe's and Weber's theoretical aims. Kracauer seeks to describe an imprecise but undeniable attraction, or compatibility, between the photographic complex and certain aspects of material reality. This attraction might be imagined at the level of chemistry itself (the interaction of illuminated surfaces with chemically sensitized film stock), and how these chemical reactions produce psychic responses in individual beholders, and thereby begin to reorganize social reality. At the same time, though, the objective rapport between the photographic apparatus and physical reality is troped in terms of social relations. Our appreciation of images that strike us as "inherently photographic" is due to a fortuitous union of medium and subject matter, the consumation of their mutual attraction and compatibility. Affinities, for Kracauer, are these observable, seemingly objective attractions which evoke for us the inherent natures of the materials involved. His "materialist aesthetics" does not deduce aesthetic criteria from known material properties, though Kracauer sometimes

[57] It is worth noting that, in his Weimar writings, Kracauer wrote a thoughtful, ambivalent critique of Weber's social thought—though he makes no mention there of the viability of Weber's "affinities." "The Crisis of Science: On the Foundational Writings of Max Weber and Ernst Troeltsch," *The Mass Ornament: Weimar Essays*, trans. and ed. Thomas Y. Levin (Cambridge, Mass.: Harvard University Press, 1995), 213-224.

presents his argument as though it did. Rather, he appeals to aesthetic intuition as a guide to theorizing a newly complex materialism. It is a materialism discovered through aesthetic appreciation, and like Goethe and Weber, it asserts creative and unconventional connections between material and immaterial realms.

While Kracauer's text is rich with case studies illustrating the internal compatibility of film with certain kinds of settings, subjects, and stories, a more recent example evokes the interplay of materialism and affinities in powerful and clarifying ways. Bill Morrison's *Decasia: The State of Decay* is an experimental, "found footage" film first screened in 2002. The film is composed entirely of elements culled from cinema's first few decades, and all of this footage is in more or less dramatic states of disrepair. This decay is itself due to diverse causes—vinegar syndrome, the whims of nitrate deterioration, water damage, solarization, molding, scorching, cracking, shrinkage and warping—which affect the images themselves in equally diverse ways. In this respect, the film offers "a veritable primer in categories of film damage."[58] The eclectic defects of the supporting medium often totally obscure the images traced in its emulsion, yet they also seem to provoke strangely emotional responses. Several reviewers speak to glimmers of melancholic identification, not simply with the human figures whose likenesses persist, faintly, beneath layers of celluloid, but with the precarious life of the medium itself.[59] Its scars, wrinkles, stutters, and warts attest to years endured, disasters narrowly survived, and an incurable tendency to age and fade and eventually perish.

[58] Cynthia Rowell, "*Decasia: The State of Decay* (review)," *The Moving Image* 5, no. 1 (2005), 144.
[59] Michele Pierson, "Avant-Garde Re-Enactment: *World Mirror Cinema*, *Decasia*, and *The Heart of the World*," *Cinema Journal* 49, no. 1 (2009): 1-19.

In line with these affective responses, several critics interpret Morrison's film as a meditation on materiality—a work insisting on celluloid's fragility and instability as its most poignant distinction in the age of digital convergence and the industrially decreed obsolescence of analog film. In this respect, the film invites comparison with other recent experimental works that stress the physical stuff, the "skin and hair" (to use Kracauer's phrase) of the celluloid strip. Mary Ann Doane singles out *Decasia* as a work that lays bare the materiality of photographic media, thereby indexing "the historicity of a medium, a history inextricable from the materiality of its base."[60] But how, after all, does this particular film go about laying its materials bare? One has a tendency to speak as though the material elements did the work themselves—that simply because they are corroded we cannot help noticing them and reflecting on the fact that they are not just virtual semblances but material objects too. But our awareness of that physicality is also solicited by the interplay between the recorded semblances and the surface structure of the medium, and how that interplay has been organized into salient, if intermittent, motifs. Our attention oscillates between the medium's physical surface and its representational layer when, for instance, a boxer hurls punches at a white void exposed by nitrate burn; when a parachuter gradually vanishes into a fog of faded film grain; a dark iris of scorched nitrate threateningly encircles a gaggle of uniformed school-children; or tendrils of mold crack through youthful upturned faces. Similarly, Morrison frequently returns to images that seem to allegorize the physical behavior and life cycle of photochemical film (figure 2). A whirling dervish bookends the film, spliced to sequences of spinning looms and reels of celluloid developing in chemical

[60] Doane, "The Indexical and the Concept of Medium Specificity," 144.

baths. A traumatic, jittering caesarian birth seems to evoke the birth of the medium itself—a birth that is dialectically answered by the fading and instability of the footage itself.

In short, the film is indexical not only in the sense of preserving physical traces (of past events and of its elements' aging), but in the sense of the finger that shows us something by pointing at it. That gesture is effected through those things to which film's "physical stuff" is supposed to be distinct: through recurring motifs, thematic juxtapositions, and other textual elements. We perceive the film's materiality through patterned correspondences (how its editing compares the celluloid film to other physical materials and processes) and our affective involvement in its surface beauty is inextricable from our mimetic identifications—even if those identifications are often tentative and unorthodox, as when we empathize with the corroded nitrate itself. *Decasia*'s theme of materiality, and its relation to the index, are in this sense mediated by a structure—a poetics—of affinities. Many of the film's most powerful images collapse the distance between original camera effects and those that have been fortuitously enhanced by the variable forms of photographic decay. Solarizations match and merge with silhouette lighting schemes; blisters of nitrate decay bubble in synchrony with the waves that crash upon a rocky shoreline (figure 3). The natural life cycle of chemical film, its materiality, is evoked through these correspondences between medium and subject-matter, ambiguously persuading us that it is like a spinning loom, like a surgical birth; that, like these things, it is physical, contingent, and "clings to the surface of things." Aesthetic affinities, in short, show us how to see film's material tendencies—they mediate and structure our sense of what that material is and how it comes to bear significance. If we find ourselves moved by these images (and many of us are), then it

further asks what this beauty reveals about our own kinship with, and affection for, a dying medium.

Revelation

For the most part, Kracauer uses the word "affinities" to describe how photography and film are attracted to certain qualities of physical reality, and how corresponding narrative forms grow organically out of those qualities. For better or worse, Kracauer never specifies precisely what sense(s) of the word he intends; he never delineates a *theory of affinities* per se. Declining to systematize this concept gives freer rein to his critical readings of films and genres, though it also risks breeding confusion. "Photography's affinities" might suggest other activities that are somehow *like* or related to photography; or it might connote processes that resemble photography; or technologies that mirror photography's mechanisms. Interpreted slightly differently, "photography's affinities" might even refer to other objective correspondences that are discovered by means of that medium—or else the "psychophysical correspondences" Kracauer mentions.[61] My reading of *Decasia* is intended to explore how our attunement to certain kinds of affinities—especially analogizing cinema to activities like textile production, whirling bodies, human births, and so on—helps us discover film's contested materiality. In other words, we apprehend that materiality aesthetically, guided by a pattern of affinities we construe at the level of the film text.

[61] Kracauer, *Theory of Film*, 68-9. Using Proust's passage on the madeleine as a paradigm, Kracauer defines "psychophysical correspondences" as covering "all these more or less fluid interrelations between the physical world and the psychological dimension in the broadest sense of the word" (69). In a given film, these correspondences are established through editing patterns and textual themes, the images being indeterminate in themselves.

I have said that Kracauer's "materialist aesthetics" is in many ways an aesthetic that produces a materialism, rather than vice versa. By the same token, if Kracauer's theory of film offers a photographic ontology, it is substantially a theory of reality itself, the contingent textures and logics of *modern* reality, as revealed by the photographic medium—that is, as revealed by photography's "outspoken affinities."[62] In this equation, the materiality of film and the nature of worldly objects are things we discover and make sense of through the media of photography and film. In this section, I will shift discussion from the reality film discovers to the revelatory effect itself—how the meaning of "revelation" changes if we focus less on notions of indexical ontology, and think more about photographic affinities. This shift in focus complicates at least one recent critique of classical film theory, and is relevant to broader debates over the proper boundary between scientific and humanistic methodologies.

In his 2008 book, *Doubting Vision*, Malcolm Turvey assesses Kracauer, Dziga Vertov, Jean Epstein, and Béla Balázs as inheritors of a romantic, "revelationist tradition." According to Turvey, these four theorists exemplify a tendency to ascribe to the cinematic medium an emergent power to "reveal features of reality that are invisible in the sense that it is impossible for the human eye to see them without assistance."[63] Taking these earlier theorists quite literally, Turvey argues that such claims consistently (and incorrectly) presume that there is something wrong with "normal human vision," and thus misuse perceptual categories. He finds that while cinema, in its capacity as a visual art, can indeed help us to notice certain features of the world around us, those features were never

[62] Kracauer, *Theory of Film*, 18.
[63] Malcolm Turvey, *Doubting Vision: Film and the Revelationist Tradition* (New York: Oxford University Press, 2008), 5.

"invisible" per se, and hence they cannot be "revealed" in the way that miniscule phenomena are revealed by the modern microscope. Thus cinema's revelatory power "is for the most part wrongly conceived of when it is compared exclusively to the scientific discovery of natural phenomena that human sight is incapable of seeing unaided."[64]

There are a number of difficulties in the details of Turvey's argument. For instance, he proposes a seemingly straight-forward distinction between suboptimal "viewing circumstances" and genuine invisibility—the difference between an item that is hidden in a drawer and a microbe that can only be viewed with a technological enhancement. One might reasonably counter that the boundary here is, in practice, far from categorical, depending on how we define or constrain "normal" viewing circumstance. A bullet in flight, for instance, is impossible to see most of the time. But with a simple technique of spark illumination, it is possible to see one with otherwise naked eyes.[65] Such a convoluted manipulation of light might strain the definition of "normal," but it accords perfectly well with the notion of altered viewing *circumstances* (as opposed to an intrinsic property of "invisibility" predicating the object itself). On the other hand, if microscopes and telescopes were to become as integral to interior decors as windows and mirrors, would it not make sense to describe microbes and planets as belonging to our "ordinary" visual universe?[66]

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[64] Turvey, *Doubting Vision*, 128.

[65] As it was developed in Germany in the latter half of the nineteenth century, this technique for observing and photographing supersonic phenomena was known as the schlieren method. Christoph Hoffmann notes that while the method was generally coupled with photography, photography "neither served as a tool for recording the 'invisible,' as it is so often claimed even today, nor was observation here irreducibly dependent on the photographic image… The phenomenon captured by the schlieren apparatus could also be studied with the naked eye by looking through the eyepiece of a telescope." "Representing Difference: Ernst Mach and Peter Salcher's Ballistic-Photographic Experiments," *Endeavour* 33, no. 1 (2009), 21-2. It is interesting that Hoffmann's analysis effectively equates photography and telescopy: either one, coupled with spark illumination, will visualize the same phenomenon.

[66] This is roughly the position of Ernst Mach, whose "sensationalist" philosophy I will address in the next chapter.

The problem with a demarcation between "invisibility" and "hiddenness" is that it treats the first as a predicate of objects and the second as a question of context. It would be at once more consistent and more persuasive to take both as relative concepts, acknowledging the "invisibility" of fleas, mites, nebulae, and atoms as no more absolute than their respective bigness or smallness.[67] Turvey's discussion of "category mistakes" drives a fundamental distinction between metaphoric and literal meanings—between "invisible" in a casual or metaphoric sense and "invisible" in a narrowly literal sense—that is supposed to obtain in everyday speech. But such sharp distinctions between literal and metaphoric usage always break down, whether we are considering ordinary language, analytic philosophy, or technical vocabularies.[68] In the end, this is the more substantial problem with Turvey's argument. He stakes his critique to implausibly literal interpretations of classical film theory's most evocative passages, justifying this literalism on the grounds that their conclusions require it.[69]

To illustrate the literal sense in which early theorists reference vision and discovery, Turvey highlights several passages in the writings of Jean Epstein, including the following in which Epstein equates the advances of the cinematograph with the progress of human

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[67] An exception might be made in the case of bodies that *in principle* cannot be seen. An atom or electron would have met this criterion at one point (vision being dependent on reflected light, which necessarily energizes and distorts such infinitesimal bodies); today, however, one would need to address the images produced by advanced electron microscopes, and judge whether these count as *revealing* subatomic particles. On such questions, see James Elkins, *Six Stories from the End of Representation: Images in Painting, Photography, Astronomy, Microscopy, Particle Physics, and Quantum Mechanics, 1980-2000* (Stanford, CA: Sanford University Press, 2008).

[68] The literature on metaphor is voluminous, to say the least. My thinking here is informed in particular by two texts in particular: George Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago: The University of Chicago Press, 1980); and the essays in Sheldon Sacks, ed., *On Metaphor* (Chicago: The University of Chicago Press, 1978).

[69] "If this were the case with theorists in the revelationist tradition proper [i.e., if their claims were intended metaphorically, not literally], then they would not arrive at the conclusions they do about the cinema" (98). Turvey extends this literalism to his readings of Stanley Cavell, Gilles Deleuze, and what he calls "semiotic-psychoanalyitic film theory" of the 1970s.

evolution, in that "the essence of living is surpassing oneself." Just as the wheel exceeds the foot in its locomotive potential, and as the propeller enhances our movement through water, so our desire to "do more than see" has prompted us to augment

> the microscopic and telescopic apparatuses with the cinematic apparatus, creating something other than the eye. Thus to consider the cinema as merely a spectacle is to reduce navigation to yachting at Meulan. The cinema is a particular form of knowing, in that it represents the world in its continuous mobility, as well as a general form of knowing because, once it addresses all of the senses, each will be able to surpass its physiological limits. Fixed, discreet notions no longer mean much to the foundations of philosophy, even to our common-sense philosophy. No more than twenty years have been spent on tentative research, and we can already measure the significance of the change that the cinema—in its expression of the external movement of all beings—has brought to bear on our thinking. Even now, we correct ourselves according to a reality where time never stops, where values only exist so long as they vary, where nothing exists except in becoming, where a phenomenon without velocity is inconceivable.[70]

Epstein's reference to "physiological limits" suggests that he is thinking about the intricacies of biologically-endowed vision, and how cinema directly enhances them by allowing us to see objects and phenomena we would not see otherwise. Thus Turvey comments,

> If it was only vision in some technical or metaphorical sense that Epstein's arguments about the failures of human sight applied to, he would not make euphoric claims like the one above about the transformative impact of the cinema on human life, because he would not be arguing that the human eye is literally incapable of escaping 'this atemporal section of the world,' or that the cinema is literally capable of doing so.[71]

This reading is frankly difficult to follow: how can we read Epstein's passage *except* as rife with metaphors? Epstein prefaces his estimation of microscopes, telescopes, and film by drawing analogies to biological evolution, technological progress, maritime exploration and, curiously, yachting. Cinema is supposed to embody, not just a technology of seeing, but certain "forms of *knowing*." Indeed, Epstein's primary concern seems to lie, not with literal modifications of vision and measurable impacts of cinema on human life, but with how to

[70] Jean Epstein, "The Cinema Continues" (1930), in *French Film Theory and Criticism, A History/Anthology*, ed. Richard Abel (Princeton, NJ: Princeton University Press, 1988), 2.64.
[71] Turvey, *Doubting Vision*, 18-9.

connect these two facts. There is, for Epstein, a definite link between how cinema occasions new visual experiences—especially when we see examples of movement in places where we had previously seen stasis—and modern society's emergent penchant for dynamic worldviews.[72]

While Turvey centers his critique on questions of sense, meaning, and rhetoric, his larger objection may really lie in how these turns of phrase are used to annex, for film theory, the prestige of scientific inquiry. In other words, the problem is not just that Epstein uses perceptual categories uncarefully or inconsistently, but that he uses them to conflate the cinema's aesthetic discoveries with those of the microscope and telescope—to "assimilate [film's] revelations to those of science" and place "film art on a par with science, philosophy, and other truthseeking pursuits."[73] But was this equivalence of cinema to microscope and telescope really claimed by classical theorists in the way Turvey says it was? Would they have conceived this equivalence as "literal," viz., that photography and cinema had revealed physical reality in exactly the way those earlier technologies had? And if so, just how far-fetched would this equivalence be? The microscope makes for an especially rich case study in the compound meanings of revelation. Experiments with magnifying lenses stretch back to antiquity, but it was in the seventeenth century that the discoveries of microscopes fully captured popular fascination, mostly thanks to the experiments of Antony van Leeuwenhoek

[72] At the risk of belaboring this point, a "worldview" is of course a metaphor. Heraclitus literally saw the same things his contemporaries saw, but he understood that shared world as unstable and in constant motion, and in that sense he "saw" the world differently. But such metaphors make sense precisely because of how they experientially resemble other examples in which we *literally* come to see something differently (from a new perspective, through corrective lenses, or whatever). The question for media theorists, then, has been whether and how dominant media—through which we may literally see different things and/or see the same things differently—participate in the transformation of dominant worldviews. This is not a commitment to literal or metaphoric senses of "seeing"; it is an effort to connect those different senses.
[73] Turvey, *Doubting Vision*, 114, 130.

in the Netherlands and Robert Hooke in England. In 1665 Hooke's *Micrographia* became the first publication of the Royal Society, quickly earning widespread popularity in England, in large part due to its startling illustrations of objects seen through the microscope.[74] These drawings portray beings previously undreamt of, like the "animalcules" (single-celled organisms previously described Leeuwenhoek) that inhabited a droplet of water, as well as enlarged views of fleas and mites, which Englanders of the era were all too familiar with, but had never beheld in such detail. For some of his most startling illustrations, Hooke chose highly common objects—the tip of a needle; a section of wool cloth; cork—and showed how unfamiliar, how unsuspected, their minute structures were. Beheld through the microscope, the smoothness and sharpness of a pin tip was revealed as a craggy topography; the fibers of wool resembled a thicket of branches and vines; cork was a honeycomb network of "cells" varying greatly in shape and size.[75]

While a pragmatic mind might have greeted such discoveries as extensions or improvements of our native powers of vision—granting that our ordinary perception is nevertheless adequate to the tasks of daily living—for Hooke, these microscopic revelations were signs that our natural senses were fatally flawed. His examples accordingly suggest that the difference between ordinary perception and observation through the microscope is one, not of degree, but of kind. The droplet of water contained teeming life where naked eyes saw an empty medium. The pin, cork, and fabric were, in the microscope, not merely enhanced in size and detail, but endowed with aspects that were totally alien to previous conceptions. The book thus anticipates the modernist ethic of defamiliarization, making the

[74] Robert Hooke, *Micrographia: or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries Thereupon* (London: Royal Society, 1665).
[75] I return to Hooke's role in the metaphor-laden ascendance of cell theory in Chapter 4.

familiar appear strange and thereby compelling us to question the foundations of our ordinary ways of viewing the world.[76] Indeed, to the extent that Hooke celebrates the advances made by scientific optics, these advances come at the price of revealing vision's genetic fallibility. The epistemological and moral consequences of this fallibility become a persistent refrain in Hooke's text. He prefaces the work by hoping that it will establish a "watchfulness over the failings *and an* inlargement of the dominion, *of the Senses*."[77] He continually reiterates the poignancy of vision's inborn shortcomings, referencing the eye's "defects," "infirmities," "frailties," "limits" and "imperfections." These somatic "defects" he both practically and symbolically links to fundamental spiritual failings: they stand as proof of humanity's original sin (an ironic proof, it would seem, given that the sin in question was eating from the Tree of Knowledge), and misguide our moral judgments and policies.[78] Because of our imperfect eyes, "we often take the shadow of things for the substance, small appearance for good similitudes, similitudes for definitions."[79]

Hooke's biblical allusions may or may not reflect the mentality of his contemporaries, but they clearly illustrates how the microscope's revelations were laden with metaphor and with symbolic import.[80] In Hooke's case, optical revelations were conflated with spiritual revelation, with the doctrine of grace and atonement, and so microscopes could play a role in correcting human observation, perfecting human knowledge and, in so doing, redeeming the

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[76] Victor Shklovsky, "Art as Technique," in *Russian Formalist Criticism: Four Essays*, ed. and trans. Lee T. Lemon and Marion J. Reis (Lincoln, NE: University of Nebraska Press, 1965), 3-24.
[77] Robert Hooke, *Micrographia*, a2r.
[78] "By the addition of such artificial Instruments and methods, there may be, in some manner, a reparation made for the mischiefs, and imperfection, mankind has drawn upon it self, by negligence, and intemperance, and a wilful and superstitious deserting of the Prescripts and Rules of Nature, whereby every man, both from deriv'd corruption, innate and born with him, and from his breeding and converse with men, is very subject to slip into all sorts of errors." Rober Hooke, *Micrographia*, a1r.
[79] Robert Hooke, *Micrographia*, a1v.
[80] Andrew S. Reynolds, *The Third Lens: Metaphor and the Creation of Modern Cell Biology* (Chicago: The University of Chicago Press, 2018).

soul of humanity. Epstein's ecstatic dreams for the cinema (and Kracauer's thesis of redeeming physical reality) are hardly out of step with this earlier ode to optical media, which Hooke, like Epstein, likens to a "reformation in Philosophy."[81] In short, scientific optics affected Enlightenment epistemologies in complex ways, complicating the "literal" sense in which new objects were made visible. When they pictured amoebas and sperm cells, microscopists brought new entities within the regime of vision. But the importance of these revelations was continuous with those (like pin tips and seeds of thyme) which instead prompted the reader to see ordinary objects with fresh eyes. These views did more than contribute new data to the general collection of empirical knowledge, they urged a fundamental revision in how we make sense of that world.

It would seem, then, is that cinema and photography *do* share epistemic features with the microscope, especially in complicating our sense of the division between the visible and unseen worlds, and in enticing theorists to attach moral significance to the terms of that division. Put another way, cinema has a sort of *affinity* with the microscope—more precisely, the rhetoric of "revelation" declares such an affinity. This means, on the one hand, that photography and microscopy are *analogous* to one another; and it means, on the other hand, that they demonstrate an attraction (in Kracauer's sense) for microscopic views. In clarifying this intermedial encounter, Svetlana Alpers's discussion of Dutch visual culture is instructive. Her analysis centers on Dutch painters of the seventeenth century, who departed from dominant Italian paradigms (which stressed narrative painting) by embracing "an essentially descriptive pictorial mode."[82] To uncover the roots of this descriptive mode, she

[81] Hooke is referring to Francis Bacon's empirical philosophy in particular, which promoted the scientific method as an antidote to superstition and prejudice.
[82] Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: The University of Chicago Press, 1983), xxi.

takes up the contemporaneous impact of microscopes, telescopes, textiles, map-making, the camera obscura, camera lucida, and a constellation of other experiments in optics. This kind of approach gives new significance to the uncanny degree of detail and accuracy in the paintings of Johannes Vermeer and other Dutch masters. Where other twentieth-century commentators have either searched for tell-tale optical artifacts or instead ignored the optical question altogether, Alpers considers the confluence of optical experimentation and aesthetic sensibility, and how these likely informed one another:

> There is a two-way street here between art and natural knowledge. The analogy to the new experimental science suggests certain things about art and artistic practice, and the nature of the established tradition of art suggests a certain cultural receptivity necessary for the acceptance and development of the new science. . . . The fact that the country that first used microscopes and telescopes had Van Eyck and other works like his in its past is not just an amusing coincidence.[83]

In speaking of "a certain cultural receptivity" that made the Netherlands fertile land for microscopic experiment, for a "descriptive" (as opposed to narrative) paradigm in visual art, and for the empirical ethos of Francis Bacon, Alpers seeks explanatory principles comparable to Max Weber's sociological turn to affinities. Optics cannot explain the direction in Dutch painting, nor did a penchant for artistic realism determine the course of scientific inquiry. But these two cultural facts do seem to have been related in meaningful and revealing ways. In the same spirit, we can enliven our sense of how photography and cinema are supposed to be linked to the discoveries of the microscope. Even if (as Turvey argues) standard examples of photography and cinema show us things that are already visible (whereas microscopes and telescopes actually reveal invisible entities), these devices are clearly affiliated in other ways. On the one hand, photography and microscopy were (along

[83] Alpers, *The Art of Describing*, 25.

with telescopes, the camera obscura, eyeglasses, etc.) family relations—filial inheritors of optical craft. Though nearly two hundred years separate Hooke's micrographic illustrations and Talbot's and Daguerre's first photographs, these achievements can be considered as dual emblems of a common thread of visual culture—a thread laid bare by the retrospective reading of "photographic effects" into Vermeer's paintings.[84] If we are inclined to claim affinities between microscopes and photographic media, it is not because they picture the same phenomena, but because they forge new links between these images and our transforming sense of the physical world. It therefore feels natural, or even necessary, to describe our sense of the emergent medium's powers by comparing it to the old, to think of the photograph and cinematograph as doing for time and movement what the microscope and telescope did for physical space. We are trying to get at a fuzzy, spiritual affinity rather than a systematic equivalence.

The affinity of cinema for microscopy consists, then, in this shared participation in revising our symbolic picture of the natural world. It is expressed in classical film theory's habit of rhetorically linking these two technologies—extolling cinema's revelatory powers through explicit analogies to those of the microscope, and through shared metaphors (images that were "teeming with life" or which "crystallized" before one's eyes).[85] These affinities can also be exemplified by the cinematic incorporation of microscopic imagery—the kind of natural or outspoken "attraction" that Kracauer documented in his *Theory of Film*. Notably,

[84] Such comparisons to photography are typified, though by no means originated, by Kenneth Clark, who describes Vermeer's *View of Delft* as "certainly the nearest which painting has every come to a coloured photograph." *Landscape into Art* (New York: Harper and Row, 1976), 65.
[85] On the circulation of microscopic analogies in the idiom of film theory, see Oliver Gaycken, "'The Swarming of Life': Moving Images, Education, and Views through the Microscope," *Science in Context* 24, no. 3 (2011): 361-80; and Hannah Landecker, "Cellular Features: Microcinematography and Film Theory," *Critical Inquiry* 31, no. 4 (2005): 903-37.

when Jean Epstein made his first directorial effort in 1922—an educational film commissioned and produced by Jean Benoît-Lévy to honor the centenary of Louis Pasteur—he made microscopic images like these a central motif. The film (*Pasteur*) sketches Pasteur's life and achievements, which are recreated by a small cast of actors in period dress. Between these brief vignettes and a number of lengthy explanatory intertitles, the film also recreates Pasteur's crucial experiments (these scenes make up enough of the running time that the work can be considered an "experimental documentary" of sorts). These experiments are treated almost as set pieces, for which the rest of the costume drama is mere pretext, and they include some very unsimulated unkindnesses to rabbits, whose lonely suffering the film weighs against the enormous virtue of curing disease.[86] They also include impressive sequences showcasing microbial spectacles of the kind Pasteur observed through his microscope (figure 4).[87]

Made just a year after the publication of *Bonjour cinema!*, to what extent might Epstein have treated this project as a cinematic experiment—an opportunity to work out in practice (and in the film's recreated laboratories) some of the theoretical principles he had been essaying in his writings? How might these microscopic visions suggest or refine the notion of *photogénie*? To what extent, finally, did Epstein—a former medical student—find in Pasteur a subject with whom he felt a more spiritual alliance (that is, an affinity), thus inviting the notion that cinematic and microscopic discoveries had something meaningful in common? In hazarding such questions, we might develop an interpretation of Epstein's

[86] Which is all well and good for the case of Pasteur's rabbit. The sacrifice endured by the rabbit we actually *see*—the performer rabbit who is compelled to reenact his forebear's fate—is for more ambiguous ends (is it for the educational benefit derived by the movie's viewers?).
[87] On the wider association of Pasteurization, hygienic discourse, and the education-film collaboration of Marie Epstein and Benoît-Lévy, see Peter J. Bloom, *French Colonial Documentary: Mythologies of Humanitarianism* (Minneapolis: University of Minnesota Press, 2008), 117-123.

Pasteur as an exercise in appreciating the cinematic medium by indulging its natural attraction to microscopic views and revelations.

The Language of Time-lapse Photography

The previous two sections have laid the groundwork for the proposition that cinema bears an imprecise but significant affinity with scientific instruments like microscopes and telescopes, and that it can reveal the world in comparable ways. This affinity is clearest when popular or educational films actually incorporate these instruments to edify and dazzle their audience. The idea of affinities can also help us conceptualize structural analogies between the cinema and other devices of discovery, indicating a network of shared roots in the visual culture of modern optics and lens-based epistemologies. As I will propose here, and develop through the remaining chapters of this dissertation, time-lapse photography stands as one of the most concrete emblems of this complex linkage between cinematic revelation and instrumental observation—especially observation through the microscope and telescope. The earliest applications of time-lapse techniques were associated with laboratory research, especially in studies of plant physiology, cytology, astronomy, and embryology at the turn of the twentieth century. The connection between time-lapse photography and scientific optics is ingrained at the level of terminology, which often specifies how time is "magnified," gathered, or "compressed," according to an analogy to refracted light.[88] These

[88] Oliver Gaycken, "The Secret Life of Plants: Visualizing Vegetative Movement, 1880-1903," *Early Popular Visual Culture* 10, no. 1 (2012), 62. Gaycken remarks on the "relative slowness with which a single term came to designate this kind of imaging," and similarly notes that "early terms for time-lapse involved a comparison to optical magnification." Elsewhere, Gaycken observes that "The German word for time-lapse, *Zeitlupe*, literally the 'magnifying glass of time,' also contains the link between the spatial and the temporal…" "The Swarming of Life," 370.

terminologies suggest a common theme of enhancement that is translated from one mode, or medium, to another. Time-lapse, or time magnification, is initially grasped as a technology that will do for time what the microscope and telescope had done for space, adapting the science of magnification to the language of moving pictures. But if we follow this analogy through, what natural phenomena—what thing or principles—does time-lapse ultimately reveal? What temporal structures does it unearth that might correspond to Leeuwenhoeck's animalcules and Hooke's cellular lattices? Moreover, what kind of process is it that does the revealing: a purely instrumental operation that literally brings new phenomena into view, or an aesthetic construction that promotes a different perspective metaphorically speaking?

Terminology offers a serviceable guide in addressing these questions and their deeper implications. Time-lapse photography has become, in English, the standard term to describe a radical acceleration of filmed movement. But there is no standard "time-lapse" speed, and the degree of acceleration in question is as variable as the range of possible subjects: the growth of a mushroom will be filmed at a different speed from the movement of clouds or the melting of snow, for example.[89] There are also no specific criteria for distinguishing "time-lapse photography" from other terms for accelerated moving images, like the silent-era practice of "undercranking" or the more colloquial "fastforwarding." While a technical distinction may not exist, it is worth thinking through the different connotations these terms bring forth. For one thing, undercranking and fastforwarding suggest relatively minor modifications of speed compared to the radical acceleration of time-lapse. More importantly, these terms have distinct pragmatic, and bodily, associations. "Fastforwarding" is rooted in

[89] An early text on motion picture techniques acknowledges this variability in frame rate as well. See Frederick A. Talbot, *Practical Cinematography and its Applications* (London: William Heinemann, 1913), 126.

the technical specificities of video, and while we may apply it to other examples of increased speed, its sense recalls the familiar operation of a VCR control panel. The term accordingly misses something fundamental to the effect in question, by locating the temporal shift in the replaying machine, not in the frame rate at which the profilmic event was captured. It is important, I think, that time-lapse effects are realized in the recording itself, in the materials that have been carefully calibrated to the process they imprint. This emphasis on frame rate locates time-lapse as an extreme case of undercranking, i.e., filming at a reduced speed so that movements will appear sped-up in projection. Undercranking suggests more modest modifications of speed, especially the wind-up toy antics of slapstick comedy, but at a technical level, it sits on a continuum with time-lapse effects. But the pragmatics of "undercranking" give it a different sense, in that it refers to the physical actions of the camera operator—the repetitive exertion of manually turning the crank at a slightly slower speed than one normally would. For standard exemplars of time-lapse techniques, on the other hand, the physical presence of a camera operator—and that operator's biological and psychological limitations—are precisely what need to be bypassed by means of automation. In practice, the technique calls for some non-human mechanism controlling frame rate—an apparatus that might involve magnets, hydraulic levers, clockwork or, more recently, computers. The extremeness of the modification in question thus seems to deny a bodily praxis, and instead evokes a disembodied, stationary, and impassive gaze.

We confront another terminological gray area when we attempt to locate time-lapse in relation to techniques of stop-motion animation. Occasionally, critics use these two terms interchangeably, as when Scott MacDonald describes the accelerated sequences of

Koyaanisqatsi (Godfrey Reggio, 1982) as instances of stop-motion animation.[90] To my thinking, it is worth maintaining a distinction between these techniques, provided that we want to distinguish their respective connections to *photography*, on the one side, and *animation* on the other. Stop-motion animation implies artistic intervention in the profilmic materials: in the time between each exposure the animator enters the space and slightly adjusts the positions or forms of her models, which might be fully manipulable clay figures (as in *The Nightmare Before Christmas* [Henry Selick, 1993]), dead insects adorning miniature props (*The Cameraman's Revenge* [Wladyslaw Starewicz, 1912]), cigarettes (*Muratti privat* [Oskar Fischinger, 1935]), indoor furniture (*Le Garde-Meuble Automatique* [The Electric Moving Company, Romeo Bossetti, 1912]), or even people (as in the music video for the *Talking Heads* song "Road to Nowhere" [dir. Stephen R. Johnson, 1985]). Time-lapse photography, on the other hand, implies that the movements transpiring before the camera are in no sense intentionally engineered—they belong to the things themselves, are organic to them (even when those things are human artifacts, machines, or social collectives, as in the aforementioned *Koyaanisqatsi*). Drawing distinctions between these techniques thus involves us in the question of whether the movements we witness are taken to be real or simulated—whether, therefore, the effect strikes us as a "trick," a delightful illusion, or as a revelation.[91]

While "time-lapse photography" is, at face value, a curious label for the effect it names—an effect of spectacular *movement*, as against the supposed stillness of *photography*—this seemingly paradoxical appellation raises questions that are highly

[90] Scott MacDonald, "*The Qatsi Trilogy*: Celebration and Warning," The Criterion Collection website, posted December 11, 2012, https://www.criterion.com/current/posts/2592-the-qatsi-trilogy-celebration-and-warning.
[91] I return to this question in Chapter 4.

germane to the technique's significance and value. After all, time-lapse effects evoke antinomies that have long haunted photographic media—of automatic versus intentional agency, of mechanical versus embodied gazes, of stillness versus movement, deception versus veracity, an implanted effect versus a true discovery—but translates them from the pictorial plane of the photographic image to the gradual unfolding of filmic movement. What does this technical compression of phenomenal time reveal? Take the example I began this chapter with, the time-lapse display of plant growth. Films of germinating seeds, sprouting leaves, blossoming flowers, form many of the earliest and most enduringly impressive examples of time-lapse techniques. These images portray buds opening into blossoms, roots extending, stems emerging, tendrils coiling, leaves sprouting—changes in the physical states of plants which had been well understood and carefully charted before motion pictures, but which were seldom seen in action, and never seen so vividly. Unlike Cohl's playful migrations of couches and bureaus, these were phenomena we know to be real, whose evidence is ubiquitous, and so catching them in the act would feel like a revelation.

In this context, the revelatory effect marks the passage from the merely known to the fully perceived, and so seems to fall short of the radical discoveries occasioned by Hooke's microscope. The technique does not seem to populate our universe with unknown, alien beings. Rather, like photography, it gives us beings we know, but permits us to see them in a new light, allows different aspects of them to dawn on us. If it does not reveal new particles or new bodies, we can still say that time-lapse photography reveals new *qualities*—what Siegfried Kracauer might have thought of as "new, hitherto unexpected dimensions of reality."[92] The time-lapse camera makes a range of reasonably well-known phenomena more

[92] Kracauer, *Theory of Film*, 10.

exciting, removing the tax on patience that observing them would normally require. Just as the microscope revealed a swarming, vivacious world beneath the restful sheen of a droplet of water, so time-lapse effects envision a world that is everywhere writhing with life.[93]

Time-lapse adds a dimension of wondrousness to phenomena that might in other circumstances strike us as mundane; it reveals, as we said, new qualities. The technique appeals to the conviction of our senses even as it shows us qualities that defy common sense—as when it suggests analogies and correspondences between disparate phenomena, or when it imputes intelligent behavior to nonsentient lifeforms. Casting the familiar world in this newly unsettled light, early time-lapse films did more than prove that flowers grow, that they incline toward sources of illumination, that their leaves often rotate and pivot over the course of a day—all of which facts were known and documented well before the invention of cinema. But when these movements were condensed into a few seconds, they took on qualities that were largely undreamt of, resembling human gestures, acts of conscious effort, dances of desire and attraction on the part of the plants themselves. These impressions were enabled by a sophisticate cinematic apparatus, but they did not affect their audiences as fanciful illusions or as curious tricks, but as profound discoveries about the natural world—a world whose autonomous beauties we had previously failed fully to acknowledge. The French novelist Colette wrote of one such film, "At the revelation of the intentional and intelligent movement of the plant, I saw children get up, imitate the extraordinary ascent of a plant climbing in a spiral, avoiding an obstacle, groping over its trellis: 'It's looking for something! It's looking for something!' cried a little boy, profoundly affected."[94] Rudolf

[93] On the broad connections between microscopic displays of "swarming life" and cinematic perception in early modernity, see Oliver Gaycken, "The Swarming of Life."
[94] Colette, "The Cinema," in Alain and Odette Virmaux, eds., *Colette at the Movies*, trans. Sarah W. R. Smith (New York: Ungar, 1980), 61.

Arnheim wrote approvingly of accelerated motion in general, as a useful "trick" for expressing certain narrative themes. Of the time-lapse film *Miracle of Flowers [Das Blumenwunder]*, however, his description turned dreamy and poetic as he described the "expressive gestures" of these plants:

> The swaying, rhythmic breathing motions of the leaves, the excited dance of the leaves around the blossom, the almost voluptuous abandon with which the flower opens. . . . Watching a climbing plant anxiously groping, uncertainly seeking a hold as its tendrils twin about a trellis, or a fading cactus bloom bowing its head and collapsing almost with a sigh, was an uncanny discovery of a new living world in a sphere in which one had of course always admitted life existed but had never been able to see it in action.[95]

Orienting these poetic flights is a commitment to the sensation of discovery and revelation, that this impression of gestural grace and deliberate action is more than an artful illusion on the part of the filmmakers. It is, in a sense, the discovery that poetry exists in nature—a discovery that, of course, can be made over and over again and in myriad ways.[96]

Knowing that Arnheim and Colette (and the various other critics and journalists who likewise indulged these human-plant comparisons) were reasonable and intelligent, we have to interpret such passages metaphorically. But if the spectacle of a plant "bowing its head and collapsing almost with a sigh" is mediated by an extended anthropomorphic metaphor, we should as what beliefs and experiences make this specific comparison possible, and what philosophical reformations it in turn enables. Before he segues by calling the film a "lucky strike," Arnheim wonders at its discovery "that the same principles applied to everything, the same code of behavior, the same difficulties, the same desires."[97] Here, then, is another possible domain revealed by time-lapse. Having distilled from nature a set of striking

[95] Rudolf Arnheim, *Film as Art* (Berkeley: University of California Press, 1957),115.
[96] I return to the spectacle of botanic intelligence in Chapter 3.
[97] Arnheim, *Film as Art*, 115.

qualities of movement, time-lapse allows these qualities to be woven into a broader language of visual analogies. Just as a film like *Das Blumenwunder* invited spectators to perceive resemblances between the movements of plants and the interpretive movements of human dancers, other applications of time-lapse techniques tend to discover other, unexpected genres of resemblance. An early montage in *Koyaanisqatsi* juxtaposes slow-motion cascades of water with time-lapse shots of fulminating clouds, the liquid movements of each formally echoing and resembling the other. Later in the film, accelerated sequences of twinkies and hotdogs streaming off assembly lines are timed to match the mechanical start-and-stop rhythm of commuters piling onto and off of mass-transit trains, and pouring down escalators. The argument to be gleaned from this visual equivalence is embarrassingly banal if spelled out in words. As a propulsive visual-acoustic experience, however, the unity of this mass-production regime compels at the level of the senses. By means of the film's carefully calibrated time-lapse sequences, we perceive not only the mechanicity and fluidity of several isolated activities, but the systematic analogies that bind habits, institutions, and routines into a "way of life."

* * *

Beginning with timely debates about the distinct indexical properties of analog and digital cinema, this chapter has contemplated the multidimensional ways in which thought about photography grounds and, even now, gives new direction to our dilemmas in thinking about cinema in general. Because the notion of affinities represents a style of theorizing that, in some sense, clings uniquely to the phenomenon of photography, I have suggested that an enriched appreciation for the philosophy underwriting this approach can breathe new air into old debates concerning materiality, realism, automatism, and revelation. To wit, these

categories are not simply virtues that the stuff of film inherently possesses, but rather are clusters of ideas to which film, in its attractions and resemblances, turns our reflections. Materiality is not a pregiven attribute possessed by film and absent in digital imagery, but is rather a quality that film plays a unique, aesthetic role in figuring for us. Neither is it a self-given power of film to reveal invisible sectors of reality, but rather, evoking its aesthetic and historical affiliation with microscopes and telescopes, film has its own ways of involving us in the *experience* of revelation. Time-lapse photography is a technique that vivifies these connections and reveals, accordingly, a system of analogies and correspondences which we understand as belonging to the natural world, and which become resources for articulating the logic of that world. Time-lapse effects form a minor subset of the language of cinema, but their distinctive affinities—for evolutionary time-scales and evolutionary connections; for the mental activity of nonsentient beings; and for the rhythmic analogies that pertain in all sectors of life—orient our perspective on the medium as a whole.

Figures:

Figure 1a-1e:Time-lapse sequence from The Secret Life of Plants *(Walon Green, 1979)*

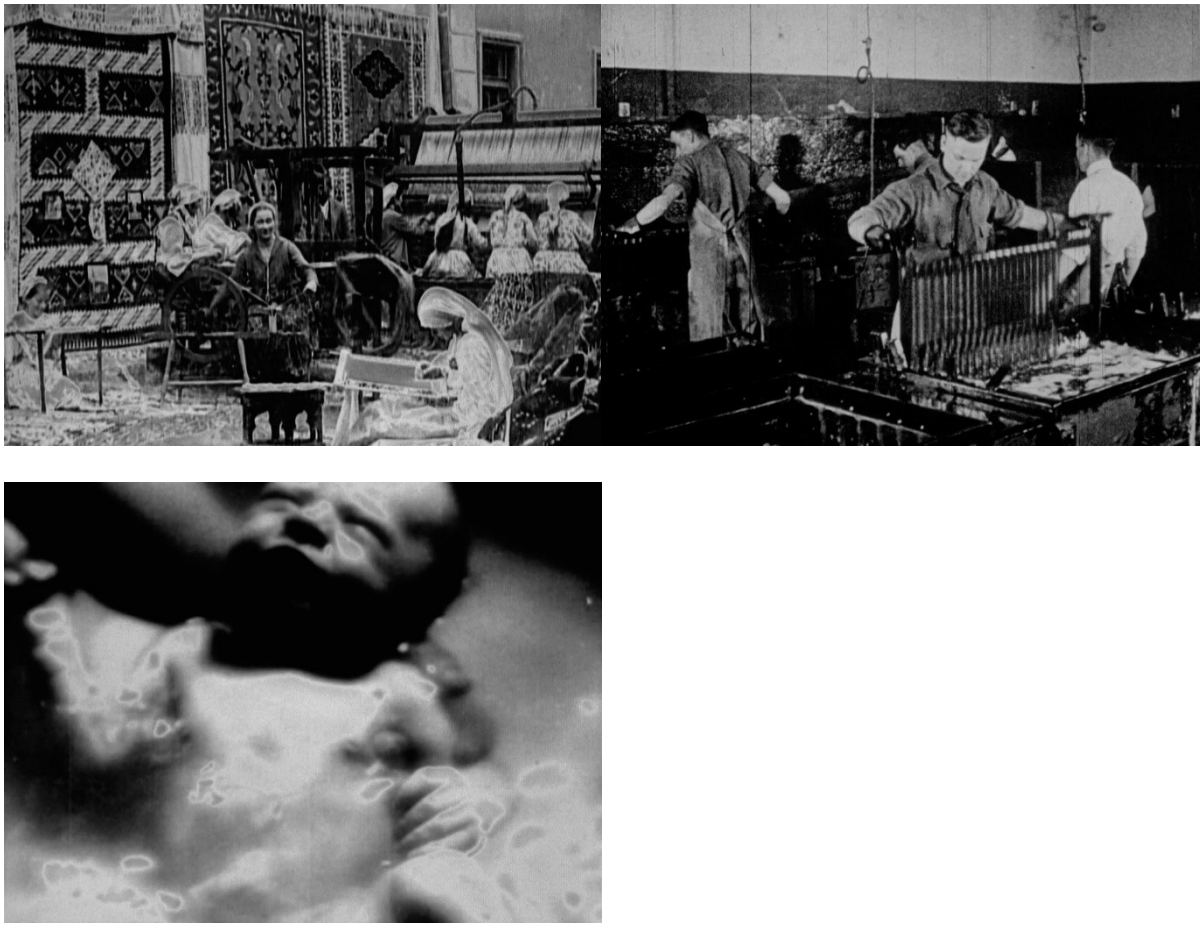

Figure 2: Decasia: The State of Decay *(Bill Morrison, 2002). Film's materiality is evoked through subjects that resemble or correspond to the medium itself.*

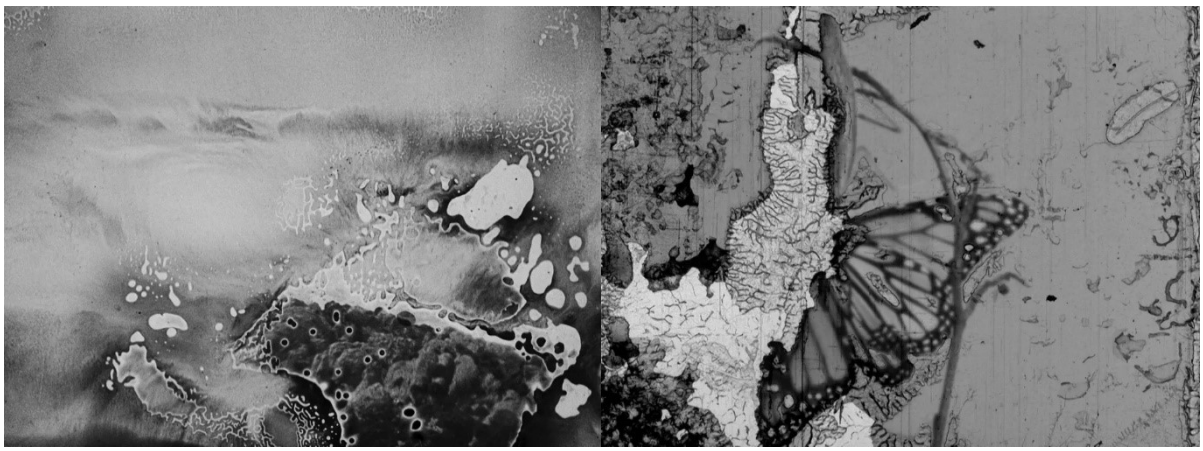

Figure 3: Decasia*. Effects of deterioration seem to resemble effects in the original image—tumultuous waves (left); the brittle wings of a butterfly (right).*

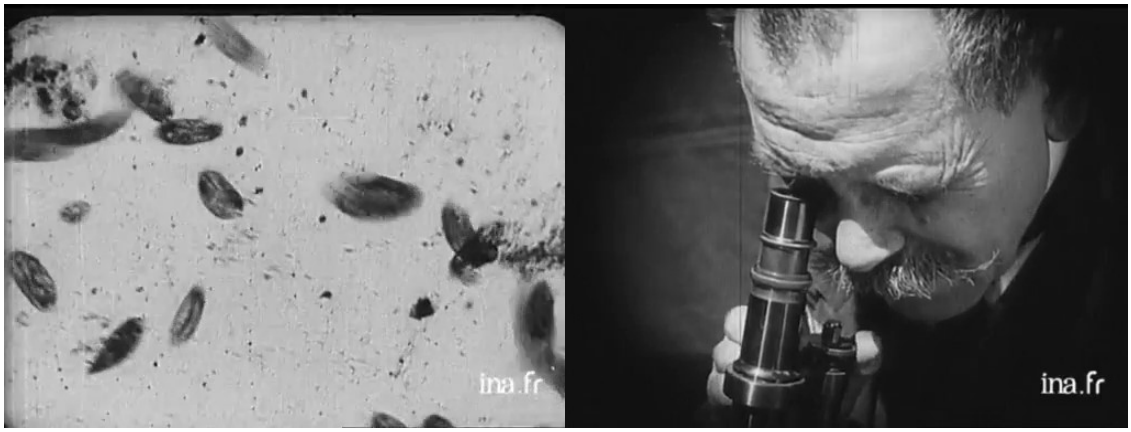

Figure 4: Pasteur *(Jean Epstein, 1922). Photogenic recreations of the famed scientist's views through the microscope.*

Chapter 2:

Marking Evolutionary Time: Marches, Fossils, and Embryos

In 1888 the Austrian physicist Ernst Mach authored a short article on the "scientific applications of photography." Stressing the primacy of immediate, "sensible intuition" to all scientific work, the article compares the photograph to other examples of scientific visualization: the curve, graphed on cartesian coordinates, that describes an otherwise amorphous collection of numerical data; the microscope, whose powers of magnification reveal a universe of invisible life; the map, which allows us to picture and find our way through unfamiliar territory; or the stroboscope, whose pulses of light isolate the discrete phases of a rapid, periodic movement—for instance, the vibrations of a tuning fork. Like these other graphical techniques, he writes, photography contributes new ways to register visual phenomena, and it can be coupled with them to produce fixed views of the infinitesimal, the cosmic, or the instantaneous. As a final example, Mach envisions another form of photography that might one day be achieved:

> Should not the principle of temporal *diminution* be of value as well? In point of fact, let us consider photographically fixing the growth stages of a plant, the stages of an embryo's development, the limbs of the Darwinian genealogical tree of the animals, and exhibiting them in a quick series of 'magic lantern slides'! What an intellectually invigorating impression that must produce, too! The images of a human being from the cradle onwards, thus depicted in his advancing development and then in deterioration into old age in but a few seconds, would have to elicit an aesthetically and ethically grandiose effect.[1]

[1] Ernst Mach, "Bemerkungen uber wissenschaftliche Anwendungen der Photographie," *Jahrbuch fur Photographie und Reproductionstechnik 2* (1888), 286. Italics in the original. Quoted by Oliver Gaycken, in "Early Cinema and Evolution," *Evolution and Victorian Culture*, eds. Bernard Lightman and Bennett Zon (Cambridge, UK: Cambridge UP, 2014), 108.

This passage on temporal diminution has been cited by several authors as an intriguing anticipation of time-lapse photography, or even as a kind of origin point.[2] Drawing on what had lately been accomplished in chronophotography, in telescopy, and in magic lantern animation, Mach conceived of a technique for recording and showing forms of movement normally too gradual to be perceived—a kind of moving image that, in 1888, was ten years away from being put into practice. It seems that this notion was more than a passing fancy for Mach, as he also consulted with Etienne-Jules Marey to inquire into the feasibility of such radically accelerated animations.[3] Indeed, such presentiments are common fare in modern histories of technological emergence, and they have long performed an important mythic function in histories of cinema. These sorts of anticipations, ideas, and dreams seemed to run ahead of their technical viability, leading André Bazin to associate them with the "myth of total cinema."[4] Besides this short article by Mach, there are doubtless many other writings that in some sense envisioned time-lapse photography years before it was achieved, which presaged its technical components, or which accurately forecasted its typical subjects.[5]

By looking into a medium's origins—whether mythic, technical, or material—we hope to shed light on it—to explain why it is the way it is (or how it functions, or why we

[2] Besides the reference by Gaycken, the passage is also alluded to in David Lavery, "'No More Unexplored Countries': The Early Promise and Disappointing Career of Time-Lapse Photography," *Film Studies* 9 (2006), 2; Janelle Blankenship, "'Film-Symphonie vom Leben und Sterben der Blumen': Plant Rhythm and Time-Lapse Vision in *Das Blumenwunder*," *Intermédialités : histoire et théorie des arts, des lettres et des techniques / Intermediality: History and Theory of the Arts, Literature and Technologies* 16 (2010), 84; and Jon Darius, *Beyond Vision* (Oxford and New York: Oxford University Press, 1984), 18.
[3] Related in E. J. Marey, *Movement*, trans. Eric Pritchard (New York: D. Appleton and Company, 1895), 312-3.
[4] Bazin, "The Myth of Total Cinema," *What is Cinema?*, vol. 1, trans. Hugh Gray (Berkeley and Los Angeles: University of California Press, 2005), 17-22.
[5] Colin Williams mentions a handful of pre-cinematic time-lapse techniques and casual statements which seem to anticipate time-lapse illusions. See "Watching Closely with Turn-of-the-Century Eyes: Obscured Histories of Magic, Science, and Animation in the Cinema" (PhD Diss., The University of Chicago, 2013), 130-173.

value it), or to uncover its "unconscious" significance, by showing how it has derived from earlier forms and conditions. This chapter gestures toward a comparable sort of genealogy for time-lapse photography by considering its affinities with a set of precursors in evolutionary science. I focus less on the technical steps leading up to the first true examples of time-lapse cinematography than on the epistemological, philosophical, and ideological reasons that would have motivated people to produce or envision such images in the first place. While other, entirely distinct genealogies are equally tenable, the present approach highlights how time-lapse ideas were enmeshed with urgent questions concerning evolution, on the one hand, and photography on the other. These ideas concern the invisibility of extremely slow and gradual phenomena (of which evolution was not only a resonant example, but also a concept that subsumed many of other local varieties of known but unwitnessed movements); questions of epistemology; of evidence; and of ontology and visualization—i.e., what sort of thing a photograph is, and how the grand and eternal dimensions of evolution might be made present to human perception. By looking narrowly, but critically, at some of the media through which evolution was first known and then popularly disseminated, I want to consider how notions of time-lapse dovetail with sequential images, which in these cases seem to aim at "photographing" evolution itself.

In taking Mach's description as a starting point, we discover time-lapse imagery entangled with questions concerning the epistemological impact of photography more broadly, and especially with nineteenth-century debates over the scientific value of photographic media. In the case of Mach's article, the physicist engages these questions by comparing photography to other scientific imaging techniques. He acknowledges that photography is *like* these other instruments—the telescope, the microscope, the

stroboscope—in that it reveals invisible worlds to our senses; moreover, it can always be combined with them, transforming the conditions of observation and measurement. Contemporary historians of science have revisited many of these same questions, examining photography's role in fundamentally revising the meaning of "observation," and in introducing "objectivity" as the dominant paradigm covering scientific images and scientific methods.[6] Photographs do not seem to have *determined* these revolutionary transitions, nor to have *caused* them in any simplistic sense. But they did emerge amid growing concerns about the limitations of human sense organs, and so they were often understood in relation to these limitations, and were enlisted as powerful metaphors in reimagining the terms of our sensual access to the universe. If, as one astronomer put it, the photograph promised to become the "veritable retina of the scientist," we must understand that promise both as a practical instrument and as a culturally resonant symbol.[7] The photograph may or may not have actually provided the scientist with objective images; but at a symbolic level, it epitomized what it would be like to observe objectively, to surpass the defects in the faculties nature gave us.

Mach's comments on the value of "temporal diminution" complicate these questions of photographic epistemology, as it is not immediately clear what *scientific* value such images might hold. His description highlights aesthetics, intellectual pleasure, and "ethically

[6] See Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2010), especially 125-174; see also Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science* (Baltimore: The Johns Hopkins University Press, 2005).

[7] The astronomer in question was Jules Janssen, who described photography as the "veritable retina of the scientist" in an article very similar to Mach's, and even more exuberant in tone. See Christoph Hoffmann, "Representing Difference: Ernst Mach and Peter Salcher's Ballistic-Photographic Experiments," *Endeavour* vol. 33, no. 1 (2009). Also see Jimena Canales's account of the changing meaning of "observation" during Janssen's attempt to photograph the passage of venus in 1883: "Photogenic Venus: The 'Cinematographic Turn' in Science and its Alternatives," *Isis* 93 (2002): 585-613.

grandiose" effects, all of which seem to describe the quality of our attention rather than any discovery rendered by the medium. The scientist nowhere claims that the device might register new data or synthesize new knowledge. One might well infer that Mach saw time-lapse photography as a powerful resource in popularizing science—a tool for demonstrating known principles and exciting lay audiences, but not really useful for research. Indeed, though some botanical laboratories experimented with time-lapse techniques at the turn of the twentieth century, their most notable applications would come in popular science films of the silent era.[8] And yet, I would suggest that this binary of "legitimate research" and "popularization" takes for granted more than it explains. What is compelling about Mach's description of time-lapse is how it makes no distinction between discovering new facts about the world and discovering new ways to take delight in it. It is significant, moreover, that his examples all reference phenomena relating to organic evolution, which had become a dominant theme in nineteenth-century thought (extending well beyond the discipline of biology), but which posed unique difficulties to the conventions of observation and evidence.

Early ideas about evolution were enmeshed in their own matrix of epistemological concerns.[9] It was increasingly felt that any natural phenomenon could be explained by its

[8] These different options are addressed by contemporary scholars working on the history of science films. To mention only a sample of this work, see Oliver Gaycken, *Devices of Curiosity: Early Cinema and Popular Science* (New York: Oxford University Press, 2015); Hannah Landecker, "Cellular Features: Microcinematography and Film Theory," *Critical Inquiry* 31, no. 4 (2005): 903-937; and James Leo Cahill "Hors d'oevre: Science, the Short Film, and the Perception of Life," *Framework: The Journal of Cinema and Media* 52, no. 1 (2011): 66-82. An important examination of how Mach himself employed photography in his experiments is Hoffmann, "Representing Difference."

[9] A brief note on terminology: by "evolution," I generally intend its wider meaning, which covers the various ways in which natural phenomena change their permanent forms over extended lapses of time. This includes the evolution of species, but does not necessarily specify its mechanism. It also includes the gradual transformation of geologic structures, the formation of the universe, the systemic adjustments of a given ecosystem, as well as the development of an individual organism (which, as several historians have noted, was what the word originally meant in English). To specify Darwin's theory of evolution in particular, I will refer either to Darwinism or natural selection (which is colloquially identified with Herbert Spencer's coinage, "survival of the fittest").

origin—that all beings lived in constant flux, were constantly developing and adjusting over time; that they had each come into being at some point in time and in their own particular way, and that they would all, eventually, expire. In some cases, scientists and philosophers sought to discover a consistent essence at the basis of these protean appearances, in the form of *archetypes*, ur-forms, transcendent natures. Such an archetype may or may not have resided in visible nature, but it was manifested in nature's varied and mutable forms, and might be discovered—or intuited—by studying those forms. For others, nature's instability pointed not to a platonic ideal but to an authentic history. In either case, organic phenomena could be understood by grasping their genesis—by seeing how they derived, either as variations on a determining, archetypal theme, or out of real, historical roots. A plant's complex and beautiful form; the variety of lifeforms inhabiting the globe; the arrangement of continents and topographies; the behavior of celestial bodies—all could be explained by describing how they had evolved from simpler beginnings and according to orderly laws. And yet, as important as origins and development had become, the motions of individual development and comprehensive evolution were equally beyond human faculties of comprehension. The horizons of human experience—with its cycles of days, weeks, and years—in no sense approximated the scales of time that framed evolutionary change. Ontogenesis was at once invested with cosmic importance, and then placed at an unbridgeable distance from our organs of perception.

Over the course of Darwin's century, scientists and popularizers worked out a visual language for expressing the grand thrusts of evolutionary history and its vital mechanisms. Its vocabulary included diagrams, fossil samples, taxonomic trees, and an abundance of vibrant literary metaphors. Many of these drew inspiration from Nature's own evocative

contrivances—the forms of extinct creatures preserved in rocky strata; the morphology of a plant, whose roots, stalk, leaves, and flowers adumbrated the course of organic development. But such figures, symbols, and visual short-hands, even as they made natural evolution symbolically comprehensible, could not close the gap between sign and referent, beholder and invisible Nature, mind and world.

The images discussed in this chapter are emblems of these epistemological tensions. They all present imperceptible orders of biological development by way of sequential illustrations. Sequential images have long been a mainstay in the armature of scientific visualization, whether to facilitate comparisons of analogous bodies, or to track changes in some single force or entity. The cases examined here—the notorious "March of Progress" iconography; the relation between fossils and geologic strata; and the thesis that animal embryos "recapitulate" the evolution of species—were informed by both of these functions. They suggest the gradual and continuous changes of species transmutation, but they do so through a static presentation that demands to be *read*. They call upon the resources of anatomical comparison—studying a series of structures and perceiving the consistencies and disparities between them—so that we might envision temporal processes that we can never directly witness.[10] Each of these examples participates in a dialectic between reading and seeing, where the act of reading summons transformative movements before the mind's eye, asks us to imagine a moving process, but which stops short of graphically rendering those

[10] Compare this to Goethe's insistence that we construe the true nature of organisms by learning "to see with the eyes of the mind, without which we must stumble around blindly, especially when researching into nature." Quoted in Robert J. Richards, *The Meaning of Evolution: The Morphological Construction and Ideological Reconstruction of Darwin's Theory* (Chicago and London: The University of Chicago Press, 1992), 34. Richards comments later on this approach to invisible nature: "Such ideal structures . . . could not be represented by particular, empirical objects; they could not be seen with the physical eye but only with the inward eye" (424).

movements or making them actually visible. In conjunction with this dynamic between *envisioning* evolutionary process and actually *seeing* it, these images also involve us in questions of correspondence, analogy, affinity, and/or parallelism. These kinds of connections were often disputed by early evolutionists—and (significantly, in my view) they have likewise proved to be recurring motifs in accounts of photographic realism.[11] I hope to develop illuminating links between the epistemological coordinates of evolutionary iconography and those of time-lapse photography, and to consider the hypothesis that time-lapse images gave new visibility to the kinds of evolutionary changes to which earlier icons had gestured. What this visibility consisted in, and what value it may have had, are questions I will address at length.

Sequential Imaging and the March of Progress

The March of Progress is almost certainly the most recognizable illustration of Darwinian evolution. Few images have been reproduced as often, parodied as relentlessly, or contested as strenuously in the decades since its entry into popular culture in the 1960s. Though variations abound, the image generally shows five or six primate figures arranged in single file from left to right, beginning with a crouched, diminutive ape and ending with a fully upright human male (figure 1). Each of these hominids is pictured in profile (sometimes in silhouette), apparently striding rightward and toward the next member in the

[11] Not only was photography sometimes thought of as the "pencil of nature" (as its co-inventor William Henry Fox Talbot put it), but it was a technology that was also thought to have a "nature" of its own—a nature which was determined by the ontogenesis of photographic images. That is, their objective and evidentiary value derived, not just from their perfect likenesses, but from the *way* these likenesses were produced. Alternatively, photography's nature could be deduced by discovering its naturally compelling subjects, and its instinctive affinity for hard, intricate surfaces.

series. Read from left to right, the sequence suggests several lines of graphic advancement: each figure stands more fully erect than the one before him, each is taller than the last, displays less bodily hair, and is more recognizably male. Though the image portrays these five organisms synchronously and in a single frame, we understand that it depicts a temporal progression: the figures march from the deep past into the hesitant future, gradually developing from primitive primate ancestors into our contemporary, sapient selves. Between these two endpoints, each member in the series represents an intermediate stage, a milestone, a known link in a continuous chain. This static image, nearly diagrammatic in its abstract simplicity, alludes to a vast, unfolding stretch of time (roughly fifteen million years); it explains our place in nature by tracing how we have evolved from our four-footed forebears, pulling ourselves up and out of the welter of the animal kingdom.

As an internationally recognized symbol of Darwinian transmutation, the March of Progress has often been targeted by modern creationists, intelligent design advocates, and other anti-evolutionists.[12] These theistic critics charge that the image indoctrinates students to a Darwinian view of human descent—that it makes the derivation of human from ape seem natural and inevitable, and that it misrepresents the supposedly sketchy evidence in the fossil record. To evolutionary biologists and scientific educators, the image is in fact no less of an irritant. Their perspective is epitomized by Stephen Jay Gould's oft-cited critique of the March, which he refers to as "a false iconography."[13] This falseness involves the unavoidable hazards of simplification—that the complexity and subtlety of evolutionary development is distorted, even bastardized, when rendered in a short-hand image. In this

[12] See, e.g., Jonathan Wells, *Icons of Evolution: Science or Myth?* (Washington, D.C.: Regenery, 2000). Wells, a proponent of Intelligent Design, uses a version of the march of progress as the cover to the first edition.
[13] Stephen Jay Gould, *Wonderful Life: The Burgess Shale and the Nature of History* (New York: Norton, 1989), 28.

case, the artistic convenience of a linear arrangement confuses the real ancestral relations between the depicted organisms, and neglects the intricate branching threads along which evolution is thought to proceed. It expresses evolutionary development as a one-dimensional path, each species linked to one before it and one to follow.[14] The March of Progress gets the fine print of human evolution wrong; but Gould's objections go beyond this perhaps unavoidable frustration with scientific popularization. The image portrays evolution as teleological—as progress toward a seemingly predetermined goal, each step an improvement over the last, thereby "reinforcing a comfortable view of human inevitability and superiority."[15]

While they represent contradictory epistemologies, Gould and the creationists both object to the March because it is so visually persuasive and because it compresses so much meaning in a deceptively simple icon. For Gould, Darwin's theory of natural selection was nothing short of an epistemological revolutionary, a paradigm shift on par with Copernicus's heliocentric theory of the cosmos in decentering humanity's position in the natural order of things. The thesis of common descent returned human beings to the animal kingdom, pulled the rug out from under anthropocentric cosmologies, and even suggested that humanity's time upon the earth had been unbearably marginal and brief by comparison to the careers of other lifeforms. The March of Progress denotes Darwinism, but its connotations adapt its

[14] Biologist J. David Archibald characterizes this distinction as one of anagenesis (straight-line succession of species) as opposed to cladogenesis (splitting off of multiple species from a common ancestor), in "Edward Hitchcock's Pre-Darwinian (1840) 'Tree of Life'," *Journal of the History of Biology* 42, no. 3 (2009): 561-592. In Gould's discussion of evolutionary iconographies, he also discusses the misleading nature of most tree diagrams as well.

[15] Gould, *Wonderful Life*, 28. The March dispenses with what is truly distinctive about Darwinian evolution—speciation as the "gradual adaptation to changing environments," driven by random mutation and selective pressure—and replaces it with a narrative that flatters our age-old assumptions about human dominion over nature (32).

message to fit the assumptions of old, conservative ideologies. Our late appearance on the scene is graphically narrated as the moment of life's fulfillment, suggesting that (as many thinkers before Darwin had assumed) the succession of lifeforms was an elaborate preparation for God's most perfect creation. The temporal succession of primates simply updates the ancient idea of a *scala naturae*—the Great Chain of Being in which there was a rationally ordained place for every known species, and every species remained enclosed in its proper place.[16] It introduces the element of time, but preserves the rationale of incremental perfection, of total hierarchy.

Studying how the March's iconography has been embraced in the popular sphere—in advertisements, in comics, in political cartoons, on album covers and t-shirts and, more recently, in the self-replicating iterations of internet "memes"[17]—we could expand this ideological critique to note how the image frequently lends itself to other triumphal narratives. Consider, for instance, how frequently one finds variations in which some new technological product is the final link in the progressive chain—the latest robotic vacuum cleaner as the culmination of broom evolution, say, or the tablet as the latest (and therefore most advanced) medium of communication (see figures 2 and 3).[18] Such images recast the capitalist cycle of novelty and obsolescence as a natural outgrowth of biological progression, perpetuating a glib "equation of old and extinct with inadequate."[19] From the commonsense truism that newer is always better, we should also note more chilling ideological

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[16] See Arthur O. Lovejoy, *The Great Chain of Being: A Study of the History of an Idea* (Cambridge, Mass.: Harvard University Press, 1936).
[17] The neologism "meme" was coined by Richard Dawkins in *The Selfish Gene* (Oxford, UK: Oxford University Press, 1976). The popular use of the term in the internet age has been an object lesson in cultural evolution.
[18] Gould discusses a number of such advertisements, including one in which the hominids finally evolve into a pint of Guinness (or have they been marching toward this desired beverage all these years?). *Wonderful Life*, 34.
[19] Gould, *Wonderful Life*, 32.

suggestions—for instance the frequent description of extant hunter-gatherer communities as "living fossils," less evolved holdovers from the Stone Age who, for whatever reason, have failed to join the European races in the parade of progress.[20] For Gould, the March of Progress epitomizes this ideological passage, in which evolutionary science becomes another implement of colonial racism, lending support to social, sexual, and ethnic hierarchies, all the while cloaked in the garb of scientific neutrality.

Gould's critique is attentive to how the March of Progress has circulated as a popular, easily aped icon of evolution-as-progress, using its many parodies to expose ideological dimensions that were less explicit in the original drawing. Moreover, the visceral appeal of the original—its vivid and seemingly obvious representation of evolutionary transformation—depends on how it echoes and incorporates earlier iconographies. Several authors have examined the many cartoons that, in the years following the *Origin*'s publication, made light of Darwin, his theory, and its implications. Constance Areson Clark notes that these cartoons generally recycled a handful of stereotypes and symbols, especially cavemen, missing links, gorillas, or the figure of Charles Darwin himself.[21] These print cartoons often contested evolutionary theory by making it appear ridiculous (e.g., picturing Darwin seated on a tree branch with his simian relatives), but in other cases the comic form served subtler ends—as an ally in critiquing social mores of the time, urging social justice or even animal welfare. But their tropic repertoire was legible precisely because it predated

[20] While a neo-Darwinian like Gould would find this presumption anathema, it should be noted that Darwin did not always discourage such conclusions, pondering the primitivism and savagery of certain races (e.g., the Irish) and musing about how modern charity toward the physically or mentally weak might, in the long run, weaken the British race as a whole. See Fae Brauer, "Framing Darwin: A Portrait of Eugenics," in *Art and Evolution: Darwin, Darwinisms, and Visual Culture*, eds. Barbara Larson and Fae Brauer (Hanover, NH: Dartmouth College Press, 2009), 124-154.

[21] Constance Areson Clark, "'You Are Here': Missing Links, Chains of Being, and the Language of Cartoons," *Isis* 100, no. 3 (2009): 571-589.

Darwin. Images of rapacious gorillas, for instance, had been in circulation since accounts of these massive apes had first reached Europe in the preceding century. Victorian satirists generally maintained this earlier connotation of bestial violence, modifying it to express the monstrous implications of Darwin's theory. Thus, the comic language of evolutionary descent was in no sense invented *ex nihilo*; it creatively reworked earlier symbolic registers, adding new layers of significance to them, but inheriting (intentionally or not) the old ones as well.[22]

What, then, are the iconographic precursors that inform the meaning of the March of Progress? The countless modern variations on this theme can be traced back to an image that was included in the 1965 Time-Life volume *Early Man*, part of the popular "Life Nature Library" series. That volume was authored by the anthropologist F. Clark Howell, and included a fold-out illustration based on a series of drawings by the artist Rudolf Zallinger (figures 4a and 4b), who was best known at that time for his panoramic murals of different evolutionary epochs. Reflecting on the image's subsequent impact, Howell later claimed that neither he nor Zallinger meant "to reduce the evolution of man to a linear sequence, but it was read that way by viewers. . . . The graphic overwhelmed the text. It was so powerful and emotional."[23] It is fair to say that the graphic dominates the captions, which are scarcely visible in reproductions of the image (see figures 4a and 4b), and which complicate the unidirectional transitions suggested by the above sequence of figures. The fourth primate in the full series, Oreopithecus, is described as a "likely side branch on man's family tree;" the seventh, Paranthropus, "represents an evolutionary dead end," as do the eleventh (Solo Man)

[22] Clark, "You Are Here," 578.
[23] Quoted in David Barringer, "Raining on Evolution's Parade," *i-D Magazine* (March/April 2006): 60.

and twelfth (Rhodesian Man).[24] The captions likewise provide information about the historical appearance of each species, like their geographic distribution and their cranial capacity. The paragraph introducing the illustration also points out a pictorial element that otherwise goes unnoticed: each of the figures has highlights on certain parts of its body, which are meant to indicate the specific bone structures whose fossil remains have been discovered, and upon which, therefore, the illustration is based. In many cases only a hip bone or a foot is highlighted; Ramapithecus has been reconstructed from a few teeth and a lower jaw bone. Such notes clarify, not only current ideas about human evolution, but the relation between science's theses and its raw materials—how ancestral portraits have been "built up" from a few fragments, how they are integrated into a larger body of facts and theories. Indeed, this is in keeping with one of the book's overarching themes, which stresses the field work of physical anthropologists and the material culture at the base of evolutionary science.

But it is disengenuous to suggest that the image contradicts the fine print in giving the impression that evolution is a "linear sequence." The illustration is labeled as "The Road to Homo Sapiens," and its introductory paragraph opens by asking "What were the stages of man's long march from apelike ancestors to *sapiens*?"[25] No doubt it was this choice of words, coupled with the striding, single-file formation of the pictured primates, that produced the "March of Progress" appellation.[26] Similarly, to speak of evolutionary detours or "dead

[24] F. Clark Howell, *Early Man* (New York: Time Life Books, 1965), 41-5.
[25] Howell, *Early Man*, 41.
[26] The phrase "march of progress" dates from at least the nineteenth century, where it most often described advancements in culture, science, or technology. The phrase is even somewhat redundant, as the OED suggests that a "march of [something]" already connotes "the general notion of moving forwards or making progress." "march, n.5". OED Online. March 2016. Oxford University Press. http://www.oed.com.proxy.library.ucsb.edu:2048/view/Entry/113953?rskey=eLXzJq&result=2&isAdvanced=true (accessed June 05, 2016).

ends" invites the notion that there is a main path from which to deviate—that human evolution is to be grasped as a progressive chain. In any event, this hominid series takes its place among the media of scientific dissemination, an object of popular science that inhabits a zone between professional laboratory practice and vulgar appropriation. It reflects this liminality, borrowing elements of scientific illustration and combining these with techniques that serve aesthetic ends. For instance, each organism in the series is shown in isolation, abstracted from any environment or inessential context, suggesting the diagrammatic look of anatomical cross-sections and scientific atlases.[27] Each species is dutifully labeled and captioned. A timeline above clarifies temporal relationships between each of these creatures. On the other hand, Zallinger's drawings are detailed and dynamic. The primates' facial expressions are mostly blank and impassive, but their physiques are full of life, displaying well-defined muscles, sinews, and bristly patches of hair. Some of them carry tools and, of course, they are all captured mid-stride, giving them a sense of propulsive movement forward. When they are composed together, their individual energies combine, creating the impression that they are pushed ahead by an irresistible force, caught in the rushing stream of morphological progress.

While contemporary variations on the march of progress theme can be traced back to Zallinger's 1965 illustration, the original "March" likewise echoed earlier scientific icons. Several writers have linked it to the frontispiece to T.H. Huxley's popular book on human evolution, *Man's Place in Nature* (figure 5).[28] That image, published a century earlier in

[27] On scientific atlases and their illustrative styles, see Daston and Galison, *Objectivity*.
[28] This comparison has also been made by several other contemporary writers. See Brian Switek, "Breaking our link to the 'March of Progress'," *Scientific American*, December 2, 2010, http://blogs.scientificamerican.com/guest-blog/breaking-our-link-to-the-march-of-progress/; Geoffrey Giller and Richard Conniff, "Iconic. Almost by Accident," *Yale Alumni Magazine*, November/December 2014, https://yalealumnimagazine.com/articles/3977/march-of-progress; and Jennifer Tucker, "What our most famous

1863, also presented five primates rendered in profile—gibbon, orangutan, chimpanzee, gorilla, and finally human. In this case only the skeletons were reproduced, with a caption crediting them to "Diagrams of the natural size . . . drawn by Mr. Waterhouse Hawkins from specimens in the Museum of the Royal College of Surgeons."[29] But the graphic analogy to the march of progress is compelling, especially in announcing a work on human evolution. As in the modern variants already discussed, Huxley's five skeletons are plotted on a single, horizontal axis, each composed in profile, with "man" (as always) occupying the right-most position. Unlike Zallinger's sequence, these skeletal anthropoids are not reconstructions based on fossil specimens, but have been selected from extant species. The image does not, therefore, purport to show a temporal progression from primate ancestors to human descendants (or at least it does not do so in the same manner as Zallinger's); rather, it invites the reader to analyze and compare the physical architecture of human beings and several primates that, in light of Darwin's theory, we should recognize as our closest animal relatives. It is a rhetorically-laden diagram, but what it argues for is *relationship*, not a sketch of evolutionary development.

And yet, despite these distinctions from the later March of Progress, Huxley's image nevertheless seems to invite kinetic and progressive readings, with one contemporary writer describing how "the skeleton of a gorilla [is] literally marching at the heels of the skeleton of a man."[30] We might chalk this impression up to the retrospective influence of later "March

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evolutionary cartoon gets wrong," *Boston Globe*, October 28, 2012, https://www.bostonglobe.com/ideas/2012/10/27/what-our-most-famous-evolutionary-cartoon-gets-wrong/drKMD5121W6EUxXJ4pF0YL/story.html.11

[29] Thomas H. Huxley, *Evidence as to Man's Place in Nature* (New York: D. Appleton & Company, 1863).

[30] Amanda Hodgson, "Defining the Species: Apes, Savages and Humans in Scientific and Literary Writing of the 1860s," *Journal of Victorian Culture* 4, no. 2 (1999): 235. Hodgson continues: "It also subliminally implies, not just synchronic similarity but also linear progress. The skeletons are drawn as if marching, all in the same direction, with the gibbon at the rear and the human leading, apparently approaching ever closer to some

of Progress" imagery, leading us to project a sense of movement onto the primates' ambiguously suspended limbs. However, even among Huxley's first reviewers there were those who described the image in dynamic (and condemning) language, as "a grim and grotesque procession."[31] What, then are the elements that allow for this impression of movement—of figures in physical motion, of gradual modification of form, and of progress toward a definite goal? To begin with, the comparison that Huxley intends to plot is one based on evolutionary descent. One understands that these are not idle comparisons, but ones that signal an off-screen process that has produced these kindred forms. The image's rhetorical force involves returning *homo sapiens* to the animal kingdom, placing our species in a lineup of suspected relatives, and alluding to a genealogical mechanism that unites them. Second, there is the fact that the primates are depicted in profile. They do not face outward, pinned and mounted, displaying their full anatomy like entomological specimens. They are rendered mid-stride—a quality that becomes much more pronounced and dramatic in Zallinger's image—as if they possessed some inner force, as if they might be on their way somewhere.[32] A third element in both images is the simple fact of sequence. These images illustrate texts aimed at an audience of educated laymen; they are, in more ways than one, designed to be *read*, from left to right, and so the placement of human beings in the ultimate position is never innocent, but always connotes a sort of finality.[33]

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evolutionary goal" (241). Also see figure 6 below, which uses the Huxley frontispiece to express the temporal progress of smart phone technologies.

[31] George Douglas Campbell, eighth duke of Argyll. Quoted in J. David Archibald, *Aristotle's Ladder, Darwin's Tree: The Evolution of Visual Metaphors for Biological Order* (New York: Columbia University Press, 2014), 16.

[32] In the first chapter of *Man's Place in Nature*, Huxley acknowledges the earlier efforts of Linnaeus to give a full account of the "man-like apes." Linnaeus's plate, reproduced by Huxley, shows these figures (cartoonish in comparison to Huxley's) in a full frontal view—perhaps reflecting the static, descriptive epistemology of Linnaeus's system. See figure 7 below, and Huxley, *Man's Place in Nature*, 22.

[33] For a comparison of between the iconicity of diagrams and that of syntactic structure, see Roman Jakobson, "Quest for the Essence of Language," in *Selected Writings II: Word and Language* (The Hague: Moutin, 1971),

While Huxley's frontispiece is not as explicitly diachronic as Zallinger's March of Progress, other images in Huxley's book present sequences tracking temporal transformation—e.g., the development of a dog embryo over three successive stages. Huxley also introduced another familiar icon of evolutionary transmutation in a lecture he delivered the following decade. The lecture, on "The Demonstrative Evidence of Evolution," focused primarily on the increasingly dense collections of fossil horses that had been unearthed in the latter half of the century, which (argued Huxley) coalesced to tell a story of continuous transformation.[34] The slide Huxley used was prepared by Othneil Charles Marsh, and it depicted gradual changes in three different sections of horse anatomy (feet, legs, and teeth), as preserved in the fossil record (figure 8). The slide has the form of a grid: six bone samples from a given generation of horses, drawn in outline, make up each row; each descending row gives the equivalent structures in an earlier genus, as if we were digging deeper into the earth's strata, and farther back into time. These figures lack the sense of self-propelled locomotion in the hominid march of progress, but they demonstrate dramatic transformations that are striking in similar ways. Consider, in particular, the evolution of the horse's foot. The bottom sample, from the dwarfish, dog-sized *orohippus*, shows a forefoot with four clearly articulated toes, and a hind foot with three. Over the ascending generations, the large middle toe becomes increasingly pronounced, while the others recede into vestigial twigs. We imaginatively behold the evolution of the modified toe we call a hoof.

345-359. For an application of Jakobson's ideas to modes of iconicity in cinema, see Peter Wollen, *Signs and Meaning in the Cinema* (Bloomington: Indiana University Press, 1972), 142ff.

[34] Thomas H. Huxley, "The Demonstrative Evidence of Evolution," *American Addresses* (New York: D. Appleton and Company, 1888), 97-128. See Also Gould, "Life's Little Joke," in *Bully for Brontasaur: Reflections in Natural History* (New York: Norton, 1991), 168-181; and Bruce J. MacFadden, "Fossil Horses—Evidence for Evolution," *Science* 307 (2005): 1728-1730.

These kinds of temporal cross-sections were part of the visual language of the life sciences in the nineteenth century, and their strategy for plotting time informs that of the March of Progress. But the visceral energy of Zallinger's image—its almost cinematic quality—recalls another relevant precursor: the time-and-motion studies of Eadweard Muybridge and Etienne-Jules Marey (figure 9). Though it is unclear whether Zallinger was aware of these images, or intended some allusion to them, I would suggest that the resemblance is more than superficial.[35] Muybridge and Marey both saw their chronophotographic experiments as real contributions to science. They adapted their photographs to the look of existing scientific images (much as Zallinger did)—seeking, as far as possible, to remove extraneous data by eliminating mise-en-scène and isolating the components of movement.[36] Part of a scientific culture that was newly committed to dissecting moving and vital processes—a culture that also produced Darwin's theory of evolution, and which was subsequently dominated by its influence—these two pioneers of chronophotography sought to analyze the continuous course of animal movement into a series of discrete stages. Compare this to Howell's framing of the march of progress as a series of "milestones of primate and human evolution"—as representative stages in a vast and continuous process.[37] Muybridge and Marey had subdivided time using means unavailable to paleontologists—no way to extract an "any moment whatever" from the flow

[35] Further complicating questions of intent is the corporate authorship of Zallinger's illustration. The book credits Zallinger only with the figures, and Howell suggests that neither he nor the artist intended to present them in a linear sequence, which implies that it was the series editors, or some third party, who ultimately did so.
[36] Mary Ann Doane, *The Emergence of Cinematic Time: Modernity, Contingency, the Archive* (Cambridge, Mass.: Harvard University Press, 2002), 35ff; and Marta Braun, *Picturing Time: The Work of Etienne-Jules Marey (1830-1904)* (Chicago: University of Chicago Press, 1992), passim.
[37] Howell, *Early Man*, 41.

of evolutionary time. But they had shown that intermittent sampling could give a spatial picture of an unfolding process.

The March of Progress, like Huxley's frontispiece, was originally presented as a comparative analysis. The accompanying text notes that "Although proto-apes and apes were quadrupedal, all are shown here standing for purposes of comparison"[38]—very much as the sizes and postures of Huxley's apes had been altered so as to highlight similarities between equivalent body parts. Both images allude to evolution as the force determining these shades of difference, a process gradually modifying the forms of kindred species. We form an idea of this process through the act of reading the image, studying and comparing animal forms. Zallinger's image goes one step further, though, in conveying evolution as dynamic and moving: we do not only compare a series of more or less similar bipeds, we read the image as a progressive transformation—as an image of apes *becoming* men, as a kinetic and ongoing "march." The "obviousness" of this kinetic reading was subsequently exploited by the plethora of cartoons and advertisements that emerged in its wake, but it is also testimony to how chronophotography and the filmstrip have established sequential images as signifiers of movement, as cells awaiting animation. In absorbing (consciously or unconsciously) the iconography of Muybridge and Marey, the March takes on the dynamism of the chronophotographic strip, combining the forward thrust of somatic movement with the subtler transformations wrought by natural selection, almost as though these individual and collective movements produced and sustained one another. There is much that is cinematic, and not just analytic, in the March of Progress.

[38] Howell, *Early Man*, 41.

Theoretical film strip samples evolutionary progress over geologic intervals—millions of years between each frame—suggesting an analogy, not only with cinema, but with the temporal telescoping of time-lapse photography. Like many time-lapse films, the March of Progress represents a natural process normally too gradual to be witnessed directly. What it lacks, of course, are the elements of photography and animation, and so it is worth considering what these two elements might contribute (really, or in theory) to the task of representing evolutionary process. In fact, we can add some perspective to this question by examining the material that formed the basis of Huxley's and Zallinger's evocative sequences—the fossilized remains of extinct organisms—and the conceptual links that have been drawn between ancient fossils and modern photographic media

Fossils and Strata, Ontology and Paleontology

Zallinger's iconic illustration of the March of Progress references a deep tradition of sequential imaging in the visual language of biology and the earth sciences—a tradition that equally informed the proto-cinematic motion studies of Muybridge and Marey.[39] In theorizing evolution—whether the reformation of the Earth's crust, the embryological development of an individual organism, or the derivation of modern lifeforms from extinct ancestors—sequential images and tree diagrams have been the most enduring visual tropes. These short-hands reveal, respectively, transitional stages in a gradual transformation, and the continuous lines of kinship binding together the thicket of living and bygone species—the

[39] Doane, *Emergence of Cinematic Time*. See also Robert Michael Brain, "The Pulse of Modernism: Experimental Physiology and Aesthetic Avant-Gardes circa 1900," *Stud. Hist. Phil. Sci.* 39 (2008): 393-417.

leaves, branches, and trunk of a newly imagined tree of life.[40] In addition to these two archetypal visual strategies, a number of recent works have examined other aspects of the visual culture that coalesced around Darwin's theory, including the abundant cartoons already described, as well as anthropometric trends in photography, imagistic passages in Victorian novels, evolution-inspired styles in painting, and Darwin's own involvement in photography as he assembled his *Expression of the Emotions in Man and Animals*.[41] This visual turn in Darwin studies confirms the breadth and variety of influence that evolutionary theory exerted on popular media, and it tells us a great deal about how evolutionary theory was understood among nonscientists. These diverse examples also point up the unique challenges that evolution posed to visualization. Even if Darwin's writing included a number of evocative images—the Hobbesian "struggle for life" which pictured nature "red in tooth and claw"; the "tangled bank" envisioned at the end of the *Origin*, in which nature's diverse and mutually dependent lifeforms describe a unified and coherent law of adaptation[42]—how to represent the eons over which this law effected itself, the strange transformations

[40] On the importance of tree diagrams and "tree of life" iconographies, see Gould, *Wonderful Life*, op. cit.; J. David Archibald, "Edward Hitchcock's Pre-Darwinian (1840) 'Tree of Life'," *Journal of the History of Biology* 42, no. 3 (2009): 561-592; Howard E. Gruber, "Darwin's 'Tree of Nature' and Other Images of Wide Scope," *On Aesthetics in Science*, ed. Judith Wechsler (Cambridge, Mass.: MIT Press, 1978), 121-140; and Julia Voss, *Darwin's Pictures: Views of Evolutionary Theory, 1837-1874*, trans. Lori Lantz (New Haven: Yale University Press, 2010).

[41] A few of the relevant texts are: Voss, *Darwin's Pictures*; Larson and Brauer, *The Art of Evolution*; Philip Prodger, *Darwin's Camera: Photography, Evolution, and Expression* (New York: Oxford University Press, 2009); Diana Donald and Jane Munro, eds., *Endless Forms*: *Charles Darwin, Natural Science and the Visual Arts* (New Haven: Yale University Press, 2009); and Jonathan Smith, *Charles Darwin and Victorian Visual Culture* (Cambridge, UK: Cambridge University Press, 2006).

[42] The first image, in word and in spirit, predates Darwin (it comes from Alfred, Lord Tennyson's poem "A.H.H. In Memoriam"), but has been applied to Darwin's absorption of Malthus, whose writings on population and scarcity informed the notions of "survival of the fittest." The second image is taken from the end of Darwin's *Origin*. The imagistic passage reads: "It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us." *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle of Life*, 6th ed. (London: John Murray, 1872), 429.

undergone by species, the flux of natural habitats, the drifting of continents and recession of oceans? Scenes of biblical creation and catastrophe had always beggared imagination in their scale and ferocity; but the oceanic expanse and imponderably slow agency of geologic time proposed a different sort of sublimity.

One response to this imaginative impasse was the emergent, popular genre that Bernard Lightman calls the "evolutionary epic," which used Classical literary forms to narrate the story of life on earth.[43] In presenting a "Darwinian Iliad" to a general reading public, these narratives "vulgarized" what modern Darwinians consider essential to evolutionary science—by, for instance, suggesting a series of great events and charismatic creatures to exemplify each evolutionary epoch, by interweaving these accounts with celebrations of the nineteenth-century prophets of Darwin's theory, by preaching a moral of ever-increasing perfection and complexity, "from monad to man," and by ensuring that a benevolent Creator was always part of the equation.[44] As Lightman puts it, these books often sought to give the reader a "bird's-eye perspective" of the wide sweep of evolutionary history—a kind of literary equivalent to one of Victorian visual culture's emblematic sites, the panorama.[45] At the same time, however, some evolutionary popularizers took a different tack, collapsing the cosmic and quotidian and conveying the grand power of natural selection by closely examining mundane objects. Grant Allen epitomized this second approach. Allen was inspired by a Spencerian conception of evolution, which encompassed "the growth of suns, and systems, and worlds, and continents, and oceans, and plants, and animals, and

[43] Bernard Lightman, "The Evolution of the Evolutionary Epic," *Victorian Popularizers of Science: Designing Nature for New Audiences* (Chicago: University of Chicago Press, 2007), 219-293.
[44] Lightman, "Evolutionary Epic," 221.
[45] Lightman, "Evolutionary Epic," 222.

minds."[46] As it worked its way down this descending scale of size and specificity, evolution was an immanent force as fully present in a walnut as it was in the solar system. Allen developed this perspective through his short essays on natural history, in which he followed a reliable formula, scrutinizing a deceptively trivial object—a walnut, a feather, a stone, a blossom—and reading its organic form to show how innocent-seeming features showed the accumulated influences of natural selection.

Allen's style begins with an intense sensory engagement with the object at hand—describing what can be known about it by touching it, smelling it, inspecting its individual textures and forms—or perhaps by relating a personal anecdote drawn from his daily routines. In the essay "Slugs and Snails," he finds his subject while gardening, as his hoe inadvertently unearths and lacerates a common slug.[47] This direct, bodily confrontation launches a mental excursion—the naturalist reflects on the moral cost of vivisection in general, on the relative capacities for suffering of humans, mammals, insects, and mollusks. He then returns to the damaged slug and notices details that usually escape attention. Here, he is reminded of the slug's hidden interior shell, which shields its vital organs (even from a vigorously wielded hoe) and which links it to its cousin, the snail. Allen *reads* his arrested subject, describes its descent from primordial snails and its filiation with modern mollusks, tracing "a curiously complete set of gradations between the perfect snail and the perfect slug in this respect; for all the intermediate forms still survive with only an almost imperceptible gap between each species and the next."[48] He divines the adaptive impulses and environmental factors accounting for these gradually accreted distinctions—the relative

[46] Grant Allen, quoted in Lightman, "Evolutionary Epic," 271.
[47] Grant Allen, *The Evolutionist at Large* (London: Chatto & Windus, 1881), 48-58.
[48] Allen, *Evolutionist at Large*, 51.

abundance of calcium deposits from which the slug forms its shell, the relative needfulness of a complete encasement—making these minor details vibrate with the comprehensive agencies of evolution writ large. Allen's mundane, concrete subjects become more significant through these evolutionary descriptions, and they contribute to the ever-expanding body of evidence in favor of evolution. In a powerful sense, they each contain the *entirety* of evolution. The whole story is mysteriously folded up in the body of a walnut, in a casual inventory of slugs, snails, bones, berries, and butterflies, and if we but pay close enough attention to these trivial things, we can begin to unfurl the grandiose fabric of the whole. As in the evolutionary epic, we gain a panoramic view of evolution itself, only in this case it is by applying a proverbial magnifying glass.

Allen's descriptive style, like his inquisitive attention to mundane surroundings, has much in common with earlier classics of natural history. His innovation was to blend these rich, untutored observations with the new teachings of Darwinian evolution—to make the resplendent, multifarious world at hand resonate with the deep time of organic transmutation. In this latter sense, it also drew on the aesthetic and philosophical legacy of European Romanticism, as that movement had flourished around the turn of the nineteenth century. Romanticism retrospectively designates a myriad of sub-movements, communities, and national strains—scientists, poets, painters, essayists, philosophers, composers, and eccentric polymaths among whom there are, pointedly, few constant features. They were united, at one level at least, by their antagonism to the previous era's dogmatic commitment to static, mechanistic cosmologies, particularly as these were identified with the clockwork universe given once and for all by Newton's *Principia.* Against these unbending formulas Romantics committed themselves to dynamism, movement, and creativity as fundamental both to nature

and to humanity.[49] They gave revolutionary importance to the detritus of everyday life—"tracing in them," as Wordsworth put it, "the primary laws of our nature"[50]—and extended this generous attention to ruins, shards, relics, and other physical bodies which marked the collision of human and geologic scales of time.[51] The influence of Romanticism stirred commutative streams of influence between the arts and the sciences, so that a writer might relish the beauty of a natural landscape while at the same time inferring the gradual forces of erosion that had formed it, the succession of seasons and years that defied human categories of comprehension. Such experiences produced aesthetic strategies for layering the "multiple tempi of nature," articulating the sensations and exertions of a country walk and making these echo the geological rhythms of erosion and deposition that had molded the surrounding landscape.[52] Through the media of natural landscapes and ancient ruins, incommensurable time-scales were made uncannily palpable, and could be made to vibrate in synchrony.

The philosophical impact of Romanticism includes this new appreciation for dynamic landscape, earthly mutability, and polyphonic cycles—a conceptual revolution that in many ways prepared the ground in which new theories of evolution (including Darwin's) would take root and gradually ripen. These novel schools of thought and methodologies were also closely connected with the study of fossils (figure 10). Fossils and strata are geological phenomena that have profoundly shaped modern conceptions of time. To speak of "deep time" is to exploit a stratigraphic metaphor, giving eons of history a spatial equivalent—one we can perceive and with which we can figuratively interact (by "mining" or "digging into"

[49] See Jacques Barzun, *Classic, Romantic, and Modern* (Chicago: University of Chicago Press, 1961).
[50] William Wordsworth, "Preface" to *Lyrical Ballads*, 4th ed. (London: Longman, Hurst, Rees, and Orme, 1805), vii.
[51] Charles Rosen, *The Romantic Generation* (Cambridge, Mass.: Harvard University Press, 1995).
[52] Rosen, *Romantic Generation*, 148.

the historical record).[53] For Darwinians working in the latter half of the nineteenth century, fossil animals (especially, as we have seen, primates and horses) offered the hardest forms of evidence with which to persuade skeptics. They formed concrete material—the physical remains of extinct organisms—that demanded to be organized and interpreted. Natural selection, it was gradually acknowledged, stood out as the most coherent, comprehensive, and economical interpretation. But if fossils now signify to us the vast and quiet agency of time, one needs to recall that it was not always obvious what they were or what they meant.

As early as the ancient Greeks, it had been conjectured that fossils—those unearthed portions of rock whose patterns resembled the forms of living organisms—were the remains of dead beings.[54] But such speculations by no means formed a consensus, and it was only very gradually that these curious, rocky fragments began to challenge orthodox worldviews. Throughout the Middle Ages, Renaissance, and Enlightenment, fossils remained enigmatic objects, and a number of alternative explanations were proposed concerning their origin: that they were only freak accidents whose resemblance to living things was an illusion; that they were preparations for future lifeforms, as if God had doodled in rock before committing his designs to flesh; or that they were abortive attempts at life, the result of mineral formations straining to organize themselves into animate creatures. As knowledge of petrifaction improved, and fossils were more generally acknowledged as animal remains, two great

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[53] The expression "deep time" is generally credited to geologist and naturalist John McPhee. See John McPhee, *Basin and Range* (New York: Farrar, Straus, and Giroux, 1980), 29 and passim. See also Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geologic Time* (Cambridge, Mass.: Harvard University Press, 1987), 1-8. Other spatial metaphors for geologic time have been in usage since at least the beginnings of modern geology.

[54] Martin Rudwick notes that the term "fossil" originally referred to any rock that was "dug up"—a meaning preserved in contemporary usage of the term "fossil fuel." Martin J. S. Rudwick, *The Meaning of Fossils: Episodes in the History of Palaeontology* (New York: American Elsevier, 1972), 1-2. The early history of ideas about fossils is concisely covered in Francis C. Haber, "Fossils and Early Cosmology," *Forerunners of Darwin: 1745-1859*, eds. Bentley Glass, Owsei Temkin, and William L. Straus, Jr. (Baltimore: The Johns Hopkins University Press, 1959), 3-29.

mysteries remained. First, there was the fact that dense deposits of marine shells were routinely found far inland, and even amid the highest peaks of Europe. Second, remains were unearthed which belonged to none of the catalogued species. As always, rival theories were given to explain these facts, and among the devout, the distribution of marine lifeforms across the planet's crust was embraced as evidence for the great flood described in the Old Testament. But other theories flirted with heresy, proposing that the earth's surface had changed, that ancient oceans had gradually receded and mountain ranges gradually emerged, and that these transformations had elapsed over, not thousands, but millions of years.[55]

Evidence of extinction was similarly unwelcome to Christian cosmology, suggesting that some of God's creatures were somehow imperfect (had ceased to fulfill their natural function, had ceased to survive), and that the Creation as a whole was subject to revision—was incomplete. Yet the core of the old system—the Great Chain of Being—survived, by incorporating the element of time. As Lovejoy described it, the Great Chain of Being was put into motion; the descriptive field of natural history became a genuine history of nature.[56] As fossil collections became denser, certain lines of organization suggested themselves. A number of geologists could not help remarking that the fossils found in the deepest strata, in those rocks known to have been formed in greatest antiquity, were also the most structurally simple; that each succeeding layer of rock showed the appearance of more complex structures; that, in short, there was a seemingly constant and direct correlation between the

[55] Interestingly, Voltaire—far from a religious dogmatist—scoffed at theories of evolving topography. Sensing how these theories conflicted with Newton's description of nature's eternal, mechanical cycles, Voltaire thought it insensible to overturn a perfectly sound cosmology "on the basis of some old shells." Quoted in Francis C. Haber, "Fossils and the Idea of a Process of Time," *Forerunners of Darwin*, 230.
[56] Lovejoy, *The Great Chain of Being*, Lecture IX.

succession of strata and the increasing complexity of lifeforms (figure 11).[57] The theory that developed out of this apparent sequence in the fossil record was one, not necessarily of transmutation, but of progression. Early nineteenth century naturalists noted that as the structure of the earth shifted, its inhabitants included increasingly sophisticated animals, with human beings emerging last as the earth's most perfect, most complete lifeform. As always, theistic versions of these theories gained purchase—proposing, for instance, a series of "special creations," with a beneficent Creator returning to the scene every few eons to introduce new species once the environment was ready to accomodate them. But the material for transmutational theories was very much in place by the turn of the nineteenth century, and was explicitly advocated by a handful of thinkers, like the French paleontologists Jean-Baptiste Lamarck and Geoffroy Saint-Hilaire.[58]

Fossils were instrumental in labeling strata, and in developing a systematic understanding of how the slow, persistent agencies of erosion and deposition had sculpted the earth's crust over vast stretches of time. At a more fundamental level, fossils ruptured traditional Western cosmologies, prompting scientists and naturalists to conceive nonhuman measures of time. These natural signs made the earth's crust into a readable text, testifying to events, forces, timelines, and movements that human beings could scarcely witness with their own faculties. As Charles Darwin expressed it in the *Origin of Species*, geology had

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[57] The history of scientific ideas correlating fossils and some version of progression is the focus of Peter J. Bowler's *Fossils and Progress: Paleontology and the Idea of Progressive Evolution in the Nineteenth Century* (New York: Science History Publications, 1976).

[58] Haber, "Fossils and the Idea of a Process of Time," 249-261. See also Toby A. Appel, *The Cuvier-Geoffroy Debate: French Biology in the Decades before Darwin* (New York: Oxford University Press, 1987). Sloan and Barzun suggest that Buffon, too, was likely persuaded of species transmutation, but hesitated to express this view in the orthodox climate of his day (choosing instead to posit his "devolutionary" thesis as a "hypothetical" idea which one "might reach" if one did not know any better). See Philip R. Sloan, "Buffon, German Biology, and the Historical Interpretation of Biological Species," *The British Journal for the History of Science* 12, no. 2 (1979): 109-153; Jacques Barzun, *Darwin, Marx, Wagner: Critique of a Heritage* (New York: Doubleday Anchor Books, 1958), 40-2.

produced "the facts leading the mind feebly to comprehend the lapse of time," and discovered unknown transformations at work in the universe.[59] Not only did fossils encourage ideas concerning the depth and remoteness of time, they soon became (along with the strata from which they were extracted) rhetorical figures for representing nonhuman history.[60] In this capacity—as figures of speech, conceptual heuristics, and objects of direct experience which allow communities to represent and relate to geological phenomena—it can be productive to think of fossils as media. They are both raw material to be worked up into robust theories, as well as middle terms translating supersensuous realities into concrete forms. Along these lines, it is telling that fossils would become durable motifs in theories of photographic media. But what justifies this analogy, and what is it supposed to illuminate about either the technology of photography, or the natural agency of fossilization?

Photographs and fossils are first of all alike in exemplifying Peirce's sense of indexical semiosis: they both signify through physical contact with, or proximity to, some prior state of affairs, and they do so because they bear the trace of external, bygone agencies. The analogy teaches us to see what is physical—corporeal; even natural, or organic—about a photograph. Just as the fossil has been formed by physical contact, attesting to that contact through an unabridged delineation of a creature's bodily form, so has the photograph been formed by a kind of contact. W.J.T. Mitchell alludes to this luminous contact when he states that a photograph is "fossilized light, and its aura of superior evidential efficacy has

[59] Charles Darwin, *The Origin of Species*, 6th ed., 354. Quoted in Haber, "Fossils and the Idea of a Process of Time," 261.
[60] Drawing on this rhetorical connection, and its historical application to both social phenomena and to measuring nonhuman timescales, Kathryn Yusoff has recently proposed using fossils to more radically rethink the geological constitution of human beings, humanity's dramatic impact on the planet (our acknowledged status as a collective agent of geologic and climatic change), and geopolitics. "Geologic Life: Prehistory, Climate, Futures in the Anthropocene," *Environment and Planning D.: Society and Space* 31 (2013): 779-795.

frequently been ascribed to the special bond between fugitive reality and permanent image that is formed at the instant of exposure."[61] Laura U. Marks similarly evokes this equivalence between photographic exposure and organic fossilization, stressing the mythic significance of "originary contact." "A fossil," she writes, "is the indexical trace of an object that once existed, its animal or vegetable tissue now re-created in stone."[62] These indexical readings often refer to the morbid artifacts—shrouds, relics, death masks, mummies, footprints—that classical theorists like André Bazin and Siegfried Kracauer turned to in describing the mysterious realism of photography. But if photographs and fossils are alike in being formed by physical contact, what is the significance of these similarities?

Walter Benn Michaels contends that the analogy exposes age old problems in photography's capacity to stand as art. Because, in his view, a work of art necessarily involves its audience in questions of intention, the ways in which a photograph is like a fossil (or a footprint, or a shadow or reflection) make us question whether its various elements were in fact *intended* by the photographer. Raising this aesthetic problem in relation to works by Hiroshi Sugimoto—in particular, an exhibition in which the artist juxtaposed fossils of a sea lily colony with photographs of those same fossils—Michaels writes that "We do not experience the fossil of the trilobite as a trilobite, but we do not experience it as a picture of a trilobite either. And if we understand photographs on the model of fossils, we cannot take for granted their status as works of art."[63] The indexical aspect of fossils—the fact that they are formed independently of human designs or intentions, that they mold a physical body

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[61] W.J.T. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* (Cambridge, Mass.: MIT Press, 1992), 23.
[62] Laura U. Marks, "Fetishes and Fossils: Notes on Documentary and Materiality," in *Feminism and Documentary*, ed. Diane Waldman and Janet Walker (Minneapolis: University of Minnesota Press, 1999), 227.
[63] Walter Benn Michaels, "Photographs and Fossils," *Photography Theory*, ed. James Elkins (New York: Routledge, 2007), 442.

automatically—reminds us, according to this argument, that human intention is similarly absented from a photograph. No matter what the photographer meant to capture in the frame, the camera's mechanism proceeds under its own power, and will inevitably capture details the photographer neither intended nor, in many cases, even noticed. To be sure, those unintended details are precisely what animate a number of the medium's most eloquent champions—the unrepeatable accidents cherished by Bazin; the *punctum* that, for Barthes, made the photograph an object of sacred fascination. All the same, observes Michaels, these valorizations of contingency, and of photography's ability to register it with unconscious grace, side-step the fundamental dilemma of art/non-art, and it is ultimately this aesthetic question that arouses our interest in the index to begin with.

Michaels's conception of "intention" deserves closer examination—and indeed, modernist art has produced numerous methods and theories that would destabilize traditional notions about artistic intention. Either way, the conceptual rapport between photographs and fossils confirms our investment in how artifacts (whether organic or technological, natural or artistic) are produced. The symmetry of fossil and photograph depends, in the first place, on the fact that they both resemble what they are of, and that they are formed by a process of imprinting. The fossil is formed, Mitchell explains, in such a way that "no physical remains of the original organic tissues survive . . . only the image or impression, a purely formal trace in which every atom and molecule of the original has been turned to stone."[64] Likewise, we can appreciate the formation of a photograph as similarly physical in nature, with the chemical reaction of light on a sensitized medium substituting for the chemistry of

[64] Mitchell, "Romanticism and the Life of Things," in *What do Pictures Want?: The Lives and Loves of Images* (Chicago: The University of Chicago Press, 2005), 172-3.

petrifaction. With respect to C.S. Peirce's triadic semiotics, fossil and photograph are alike in combining iconicity and indexicality—each resembles its referent and has been formed through some kind of contact or proximity to it. To be more precise, the photograph or fossil resembles its referent *because* of its contact with it.[65] The analogy assumes our familiarity with fossilization in order to help us make photographs seem less familiar—to see them as not just paper likenesses, but as physically molded objects asserting a mysterious, perduring presence.

Even at this point about indexicality, however, it is worth making some qualifications. Gently resisting this sense of the photograph as a mold or impression, Stanley Cavell notes that "physical molds and impressions and imprints have clear procedures for getting *rid* of their originals, whereas in a photograph, the original is still as present as it ever was."[66] A girl photographed will continue to live as before, outwardly unaltered, alongside her photographic portrait—though in time she will inevitably age and die in ways that her photographic likeness will not. In this respect a fossil is different: a dinosaur cannot live contemporaneously with its fossilized remains; the fossil is, by definition, formed by *converting* organic substance into rocky matter. It is relatively unmysterious to claim that a fossil is not just an image of an organism, but in fact *is* that organism—it is not a substitute or a sign indicating the organism, it is one and the same being, materially transformed.[67] A fossil is, by definition, an inert semblance that *replaces* a living original.

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[65] The photograph/fossil's iconicity becomes a kind of a meta-sign: iconicity *signals* indexicality, clarifies for us what kind of sign the photograph/fossil is. On metacommunication and logical typing of communicative signals, see Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (Northvale, NJ: Jason Aronson, 1987), 203-227 and passim.

[66] Stanley Cavell, *The World Viewed*, enl. ed. (Cambridge: Harvard University Press, 1979), 20.

[67] By comparison, Bazin's claim that the photograph "is the object itself, freed from the conditions of time that govern it" is a phrase that often mystifies his readers. See "The Ontology of the Photographic Image," *What is Cinema?* Vol. 1, 14. Translation slightly altered.

A number of theories—especially those based in philosophical aesthetics—focus exclusively on a photograph's deterministic bond to its referent, where the "referent" is often restricted to "the physical object(s) in front of the camera's lens." Time, in these accounts, is something seen *through*, it is a medium made transparent as air by the mechanism of the camera. This temporal transparency is what Barthes alludes to when he remarks, of a photograph of Jérôme Bonaparte (Napoleon's youngest brother), that "I am looking at eyes that looked at the Emperor").[68] The fossil metaphor alludes to, and complicates, this uncanny temporality of photographic media. This is the spirit in which Deleuze expresses the unsettling quality of some cinematic images, likening them to "strangely active fossils, radioactive, inexplicable in the present where they surface, and all the more harmful and autonomous."[69] Films and photographs are not just fossil-like in resembling and embodying their mortal referents: they also uncannily outlive them. We encounter these media as remnants of an undead past, and so they signify other ways in which the past haunts the present. This affinity between photography and the (un)dead is apparent in the Bazinian analogs mentioned above, which return in subsequent writings by Susan Sontag and Roland Barthes, and which form the obsessional core of Laura Mulvey's *Death 24x a Second*. Mulvey writes: "Just as the cinema animates its still frames, so it brings back to life, in perfect fossil form, anyone it has ever recorded, from great star to fleeting extra."[70] In the context of Mulvey's reflections on cinema, the link to fossilization is threefold, characterizing the lively persistence of the figures inscribed in classic films, the conditions in which we now encounter those films, and the ways in which the films themselves seem to

[68] See, e.g., Kendall Walton, "Transparent Pictures: On the Nature of Photographic Realism," *Critical Inquiry* 11, no. 2 (1984): 246-277. The quote from Barthes is from *Camera Lucida* (New York: Hill & Wang, 1981), 3.
[69] Quoted in Marks, "Fossils and Fetishes," 227.
[70] Laura Mulvey, *Death 24x a Second: Stillness and the Moving Image* (London: Reaktion, 2006), 18.

anticipate and allegorize their own uncanny temporality. In films like *Vertigo* (Alfred Hitchcock, 1958), *Voyage to Italy [Viaggio in Italia]* (Roberto Rossellini, 1954), and *La jetée* (Chris Marker, 1962), the medium seems to seek out the same kinds of analogs favored by its theorists—volcanic remains, fading monuments, taxidermically preserved animals, and tree rings—investing them with crucial narrative significance and making them the locus of mournful or traumatic gestures. The metaphoric sense of fossils, then, expands beyond what they inwardly are, and alludes to the kinds of situations in which they are encountered: as sticking up out of the ground following an earthquake, debris from distant times surfacing in the present.

We use fossil analogies to work out problems concerning indexicality (the causal bond between image and referent) as well as the complex temporalities of film and photography. As Philip Rosen has pointed out, indexicality is itself a temporally complex category. We most often think of it as expressing film's historicity, and yet in Peirce's semiotic scheme it covers a range of different temporal relations between sign and referent and between sign and interpreter.[71] The footprint is one favored example: a physical imprint signifying some terrestrial creature, it is formed in the time it takes for that animal to plant and lift its paw, and it is encountered some lapse of time after the moment of its formation (perhaps hours or days, or, if it is a fossilized footprint, millennia). In the case of a weathervane, on the other hand, the relation is simultaneous all the way round: it signifies because the wind blows against it at the same moment that we regard it. Finally there is Peirce's less remarked example of a sailor's "rolling gait," which gives away his occupation

[71] Philip Rosen, *Change Mummified: Cinema, Historicity, Theory* (Minneapolis: University of Minnesota Press, 2001), 20.

in the moment we recognize it, but which we must understand as having been formed quite gradually, over years of somatically and habitually adapting to the unstable bearings of a seaborne vessel.[72]

While photograph and fossil are alike in persisting as vivid remnants of perished beings, the temporalities they signal could not be more different. Photographs define our sense of the instantaneous, of the "tenth of a second." Even when they involve prolonged exposure times, we still tend to relate to them as immobile slices removed from the flow of time.[73] By contrast, fossils require, and necessarily connote, the years over which they have been formed. We think of them as imprinting, not just the formal outline of a given organism, but the eons of time that have elapsed since the epoch of their flourishing. They do not simply irrupt into the present after a great interval: their whole significance lies in their having *endured* those accumulating years, actually embodying them, folding time up into innumerable mineral pores. Fossils are almost never the perfect, molecule-by-molecule reproduction of the original, as Mitchell describes them. The fossilizing process tends to preserve only hard surfaces (bones, shells, beaks) rather than soft ones, and even these are generally reduced by the ravaging years to a solitary rib or tooth. Ancient monsters are represented by these bits and pieces of remaining matter, or else they are composited from several different sets of remains. The fossilized organism similarly takes on a monumental representational burden, standing not just for the individual beast whose remains it is, but for an entire species, cataloging its impermanence in the archives of nature.

[72] Each of these examples are discussed by Rosen, *Change Mummified*, 18-20. The example of the sailor is also mentioned by Wollen, *Signs and Meaning*, 122-3.
[73] Thierry de Duve, "Time Exposure and Snapshot: The Photograph as Paradox," *October* 5 (1978): 113-125.

In short, fragmentariness is fundamental to what fossils are and to how we have encountered them over the years. Their significance therefore calls upon complex hermeneutic strategies—making sense of them means reading their forms, studying their patterned arrangement in layers of rock, discovering how they have been formed and deposited over millennia. They demand creative procedures for filling in gaps. This was one of Georges Cuvier's great accomplishments—reconstructing full skeletons of extinct species based on the partial collections of fossils; applying the resources of anatomy to the possessions of paleontology and, alongside these museal reconstructions, espousing a theory that gave robust meaning to those scattered, fugitive bones.[74] In a similar spirit, Charles Lyell (the geologist whom Darwin later cited as a formative influence) proposed new ways for reading the fragmentary text composed by the earth's strata. Rather than associate radical interruptions between strata with sudden catastrophes, Lyell "interpolated time and process" into those gaps, making them stand for grand stretches of geological development.[75] Fossils and strata only gradually became legible as signs of deep time, and in doing so they implanted human history within a set of processes that were inaccessible to our senses. They were rock objects that could be striking and beautiful on their own terms; but in recognizing them as the remains of ancient beings, they became symbols of cosmic duration and raw material to be worked over and integrated into increasingly comprehensive theories of evolution.

The affinity between fossils and photographs expresses our investment, not just in ontology or indexicality, but in ontogenesis—how a given object or work or artifact has been

[74] See Rudwick, *George Cuvier, Fossil Bones, and Geological Catastrophes* (Chicago: University of Chicago Press, 1997).
[75] Haber, "Fossils and the Idea of a Process of Time," 257.

produced, the specific forces and agencies that have formed it, and how it signals or embodies those forces. One might feel, as Michaels does, that this deflection from indexicality to causation is ultimately "indexicality approached from another angle," another way to articulate the difference between a wayward, worldly imprint and an intended, meaningful *work*.[76] But the dialogue between photographs and fossils reminds us of the intricate layers of time that are part of that causal matrix—they are icons that resemble their subjects, and which embody, more subtly, the generative forces and sections of time that have generated them. This dialogue also speaks to what we might call our *ethical* investment in photographs. This ethics might be social, cultural, and historically specific—governing, say, the conditions under which a photograph can count as evidence. Or it might be the personal, subjective ethics evinced by Barthe's melancholic ruminations—the almost incommunicable shudder he terms the *punctum*. In either case, the ethics is informed by the etiology: we care about a photograph (or a fossil) because we know how it was formed, taking for granted that, no matter its pictorial qualities, it is an image originating out of a moment of exposure to something in the world.[77] The case of fossils grounds this appreciation of how a likeness has been created. Fossils signify pastness to us because we know them as the remains of formerly living bodies, detailed likenesses scored into rock over the course of many years. But their full meaning—as hard evidence of geologic shifts and

[76] Michaels, "Photographs and Fossils," 436.

[77] To present readers, this characterization may sound antiquated with respect to the contemporary dominance of digital media. It has been remarked all too often that our visual media no longer command the authority they used to, and that this is either a bad thing (we have therefore forfeited our historical consciousness) or a good thing (in that fact and fiction need to be established through strong social protocols, not via a medium's purportedly authenticating properties, and this was always really the case anyway). My point here is merely to stress that the difference does not reside in how an image is really formed, but in our *conception* of how it has been formed, and the practical experiences that account for that conception. Digital images may not be ontologically distinct from analog ones, but our modes of interacting with them are in an important sense different, so our *sense* of their etiology has changed.

biological evolution; as emblems of the depth and gradual agency of time—had to be worked out and contested over the course of decades, with even so modern a mind as Hegel refusing to acknowledge them as the remains of former beings.[78] As a last point, we might also take a step back and consider what this felt correspondence between photographs and fossils might, to different minds, signify in itself. Why might it be important that seemingly disparate phenomena—the technical, modern means of fixing images via photochemistry; the organic, eternal process through which hard surfaces convert to rock—correspond in some way? What meaning is contained in that mysterious echo? This question will be addressed, from a slightly different angle, in the following section.

Through this discussion of fossils—their symbolic association with other graphic and inscriptive media; their capacity to represent evolutionary time through their spatial placement within terrestrial strata—I have highlighted the role they played in making deep time and gradual phenomena legible. In early theories of geological or biological evolution, mention is often made of the frustrating invisibility of these phenomena, and of how this gap between knowledge and sensation will inevitably frustrate attempts to persuade skeptics. Being cognizant of these kinds of transformative changes, attempts were made to give greater visual contour to these processes—to *envision* them, if not actually to see them; to call them up as a virtual spectacle before the mind's eye. Theories of evolution animated the fossil record, in the sense that they gave these strange objects new, systematic, even cosmological significance. But one is also interested to know how these thinkers conceived of giving real motion to these ideas—not just to study their present results, but to picture them in action.

[78] Hegel ascribed fossils to an "organo-plastic Nature which generates the organic . . . as a dead shape, crystallized through and through, like the artist who represents human forms in stone or on flat canvas." Quoted in Mitchell, "Romanticism and the Life of Things," 178.

The middle term which acted to put these inert shards in motion was, it turns out, another form of development that was also known through discrete stages: embryogenesis.

Animating Embryos: Recapitulation

As we have seen, the march of progress and other dominant icons of Darwinism tend to picture evolution as a process with a direction. In many ways, this tendency goes back to efforts in the early 1800s to read the evidence embedded in the earth's strata. The increasingly legible fossil record seemed to demonstrate that nature had a history—that the surface of the earth had altered over the years, that the planet's flora and fauna had similarly transformed, and that these changes were not haphazard. The succession of species showed an undeniable progression from simple protists, to multicellular organisms, to fishes, amphibians, mammals, and finally humans. This evident progress in the direction of life was understood in a number of distinct ways in the decades before Darwin published his theory of natural selection; indeed, the most well-regarded theories denied the actual evolution (or "transmutation") of species.[79] For many scientists, it was easier to fathom a series of miraculous creations every few millennia than to suppose that the simpler species somehow spawned or gave rise to subsequent, more complex ones. Today's evolutionists would reverse this equation—identifying evolution as the mechanism that has produced all the earth's lifeforms from distant ancestors, but insisting that the process has no set course, no

[79] Bowler, *Fossils and Progress*.

predetermined goal, producing variation along myriad branches, but in no sense *progressing* in a given direction.[80]

These earlier, directionalist readings of the fossil record often took the form of a vague but seductive analogy, comparing the progressive sequence of species to the stages of an individual organism's development. Analogies between the phyletic series and embryogenesis were often painted with a wide brush, but following Darwin, they took the form of a universal law directing research in both paleontology and embryology. The so-called biogenetic law was immediately controversial, and was in time abandoned by working scientists, and condemned by historians. Yet its English translation remains curiously familiar: ontogeny recapitulates phylogeny; that is, "animals in the course of their embryonic development pass through stages corresponding to the mature forms lower in the scale."[81] Much has been written against this thesis of recapitulation. Recent commentators contend that, besides its remoteness from the methods and standards of legitimate science, it was a theory mired in racist ideology, perhaps even contributing to the genocidal movements of the twentieth century.[82] These ideological ramifications are important to weigh, but extend far beyond the parameters of this chapter. My focus in this section is more narrowly on the

[80] One way to capture this modern mood in evolutionary theory would be to say that it rejects teleology. It should be mentioned, as a point of nuance, that not all progressive theories of evolution are teleological. Lamarck, for instance, opined that evolution was driven by the individual efforts of organisms who successfully passed on their acquired characteristics—that, therefore, organisms were increasingly refined, increasingly perfect. But they were not progressing toward any predetermined goal, they had no final cause, and therefore no true *telos*.

[81] S.J. Holmes, quoted in Owsei Temkin, "German Concepts of Ontogeny and History Around 1800," *Bulletin of the History of Medicine* 24 (1950), 241n.

[82] Gould situates Ernst Haeckel's influential thesis of recapitulation with respect to the latter's "belief that harsh, inexorable laws of evolution ruled human civilization and nature alike, conferring upon favored races the right to dominate others," thereby contributing directly "to the rise of Nazism." *Ontogeny and Phylogeny* (Cambridge, Mass.: Balknap, 1977), 77-8. Gould cites and reinforces earlier arguments linking Haeckel and Hitler, mainly Daniel Gasman, *The Scientific Origins or National Socialism: Social Darwinism in Ernst Haeckel and the German Monist League* (London: MacDonald, 1971).

philosophies and worldviews that grounded these theories of parallelism in the early nineteenth century, and the visual logic suggested by these imaginative modulations of the tempi of organic development.

Recapitulation is now defunct as a scientific thesis, and the parallels it describes have always attracted controversy. But whatever its current reputation, it was by no means a marginal or esoteric notion during biology's formative years. A 1911 survey listed seventy-two different scientists who, between the years 1797 and 1866, entertained or asserted some kind of parallel between the course of embryonic development and the succession of fossilized species.[83] This broad analogy was expressed in radically different ways, however—was more or less developed in its details, and was invested with more or less significance. Among working biologists there were those, like the physiologist Johann Friedrich Blumenbach, who used recapitulation to demonstrate the existence of a *Bildungstrieb*: a single form-giving force, active at all levels of the universe, which guided the development of individual organisms, the historical series of species, as well as the organization of inorganic bodies.[84] A similar three-fold parallelism between the "history of the earth, the existing pattern of mature organisms, and the stages of embryonic development" was put forward by the comparative anatomist Carl Friedrich Kielmeyer.[85]

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[83] The list, compiled by J. H. F. Kohlbrugge, is cited by Jane M. Oppenheimer in "Embryology and Evolution: Nineteenth Century Hopes and Twentieth Century Realities," in *Essays in the History of Embryology and Biology* (Cambridge, Mass.: MIT Press, 1967), 207. Oppenheimer suggests that one could probably count far more than 72.

[84] Blumenbach defines the *Bildungstrieb* as follows: "there exists in all living creatures, from men to maggots and from cedar trees to mold, a particular inborn, lifelong active drive [Trieb]. This drive initially bestows on creatures their form, then preserves it, and, if they become injured, where possible restores their form. . . . It shows itself to be one of the first causes of all generation, nutrition, and reproduction." Quoted in Robert J. Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: The University of Chicago Press, 2002), 218-9.

[85] William Coleman, "Limits of the Recapitulation Theory: Carl Friedrich Kielmeyer's Critique of the Presumed Parallelism of Earth History, Ontogeny, and the Present Order of Organisms," *Isis* 64, no. 3 (1973): 341-350. While Kielmeyer's thesis of three-fold parallelism influenced a generation of German biologists, Coleman

Meanwhile in France, the anatomist Geoffroy Saint Hilaire—whom Darwin later included among his most important transmutationist precursors—drew on the example of the tadpole, which gradually sheds its tail and sprouts legs as it matures, to theorize the historical evolution of fish into lizards and finally into quadrupeds.[86] From the other side of the evolutionary debate, Karl Ernst von Baer, the founder of modern embryology and a fervent anti-Darwinian, chided those who made "a bold generalization from a few analogies, that the higher animals run in the course of their development through the lower animal grades."[87] And yet von Baer had proffered his own law of development, asserting that organic structures develop from general to particular forms, which inspired subsequent theories of parallelism in England and Germany. Indeed, though he was committed to the fixity of species, von Baer readily applied the goal-directed actions he observed in embryos to the history of life: "It seems to us unmistakable that the gradual progression of organisms to higher forms and finally to man was a development, a progress toward a goal."[88]

During this period, there were numerous other statements asserting these kinds of parallels, and they exerted a significant influence on Charles Darwin, Alfred Russell Wallace, and other emerging evolutionists. Recapitulationists could be found in England, France, and among other Europeans and Americans. As the handful of examples cited above would suggest, however, such theories were especially prevalent among the Germans, and

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argues that Kielmeyer himself was actually ambivalent about it—considering it one of the life sciences' foremost priorities, but finally deciding that it could not be demonstrated satisfactorily.

[86] Reijer Hookyaas, *Natural Law and Divine Miracle: The Principle of Uniformity in Geology, Biology, and Theology* (Leiden: E. J. Brill, 1963), 85, 108.

[87] Von Baer, quoted in Jane M. Oppenheimer, "An Embryological Enigma in the *Origin of Species*," in *Essays in Embryology*, 231.

[88] Von Baer, quoted in Lynn Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900* (Chicago: The University of Chicago Press, 1995), 118-9. Von Baer's stance on evolution has earned considerable discussion, but his antipathy centered on the mechanism of natural selection, which he thought intolerably random and haphazard. See also S. J. Holmes, "K. E. Von Baer's Perplexities over Evolution," *Isis* 37, no. 1/2 (1947): 7-14.

had a complex kinship with German Romanticism and, in particular, with the school of *Naturphilosophie*. The influence of *Naturphilosophie* on German biology is well documented, and historians have generally treated it as a hindrance to scientific progress—a delusory infatuation with mystical ideas that had no place in the laboratory and, all too often, clouded the perspectives of otherwise bright investigators. But as Robert J. Richards has recently argued, these earlier accounts dismiss *Naturphilosophie* without properly appreciating its philosophical grounding or the character of its influence on the life sciences.[89] The term itself derives from the writings of Friedrich Schelling, who sought to rework the central antinomy in Kant's critical philosophy. Where Kant erected a screen between self and world, such that phenomenal reality was always warped and forced to fit the innate architecture of our receptive minds, Schelling imagined a more intimate congress between mind and world. The universe presented itself as "a harmoniously unified network of integrally related parts," and this harmony—which Kant understood as the projection of mental order *onto* nature—Schelling's philosophy conceived as a fabric incorporating human beings, human minds, and "mind" or "spirit" [*Geist*] as such.[90] Such a worldview upended Kant's, but it was grounded in the latter's own discussion of teleology and aesthetics. For Kant, organisms could only be conceived teleologically: the organism had to be grasped as a unity composed of subservient parts (organs, tissues, humors); and these parts only made sense in terms of the whole, the individual, whose life and homeostatic balance they maintained. Teleological understanding meant a reciprocal, dialectical attention to means

[89] Richards treats this influence most extensively in *The Romantic Conception of Life*. This book goes into unexpected depths in recounting the influences, ideas, political commitments, and biographies that made up German Romanticism, which helps to reorient its influence on biological science, and the value of this influence.
[90] Richards, *Romantic Conception of Life*, 10.

and ends, the whole and its parts; the organism had to be studied *as if* it were the product of some plan, as if it had been formed by a creative mind. Organisms in this sense mirrored artistic creations, suggesting a "logical symmetry between teleological judgment and aesthetic judgment."[91] For Romantic biologists, teleology and aesthetics offered complementary paths into the heart of nature since "the forces that created nature and gave her form would be revealed . . . to be the same as those that created aesthetic objects and endowed them with beauty."[92]

This philosophical scheme was founded on the identity between mind and nature—that all beings, organic and inorganic, possessed mental and material attributes; that, as Schelling put it, "Nature should be visible mind, mind invisible nature."[93] Mind and world mirrored each other in perfect harmony—they were analogs—and this identity was expressed through various other kinds of phenomenal correspondences. It was only natural, then, that the process of embryonic development would resemble that of animal evolution: both were rooted in the common fabric of becoming, confirming the rational, intelligent ordering of nature. They were anchored in the parallel development of self and nature, wherein a mind comes to know and define itself by exploring an unfolding and enveloping environment.[94] In this light, we can appreciate how recapitulation does not violate the procedures of authentic science, per se: rather, it epitomizes a different conception of science, one whose affinities for art and philosophy have largely gone the way of the frog's discarded tail, or the horse's extraneous toes. Notions of parallelism were organic outgrowths of a worldview that sought out striking and harmonious analogies, which made correspondence the criterion of true

[91] Richards, *Romantic Conception of Life*, 12.
[92] Richards, *Romantic Conception of Life*, 114.
[93] Quoted in Richards, *Romantic Conception of Life*, 137.
[94] Richards, *Romantic Conception of Life*, 13.

knowledge, and which replaced Newton's clockwork universe with a vibrant, dynamic, intelligent, and constantly evolving nature.

Theories of parallelism like Blumenbach's and Kielmeyer's formed biological counterparts to Johann Gottfried Herder's philosophy of history, which similarly explained the apparent congruence of ontogenesis and geologic history by appealing to a single creative force operative at all levels (and at all times) in nature. This complex of thought about genesis, growth, and transformation influenced the theoretical outlook of various later *Naturphilosophen*, giving totalizing importance to more specific studies of animal morphology. Following the publication of Darwin's *Origin of Species*—which, in important ways, also bore the marks of this romantic influence—theories of parallelism took on a new flavor: they found their unity, not only as twinned expressions of a common principle, but as links in a temporal, causal chain. As zoologist Richard Goldschmidt later reflected, "Evolution was the key to everything—There were no creation, no God, no heaven and hell, only evolution and the wonderful law of recapitulation."[95] Parallelism became most systematic, and most controversial, in the hands of Goldschmidt's teacher, the Prussian zoologist Ernst Haeckel. Haeckel's version of Darwinian natural selection made the evolutionary legacy of *Naturphilosophie* explicit, recruiting Goethe (his poetry as well as his amateur forays into botany, morphology, and perceptual psychology) as an early evolutionist, and quoting lyric stanzas to introduce Darwinian interpretations of the cosmos. The controversial impact of Haeckel's biogenetic law centered, not so much on his poetic and painterly excursions, as on the meaning of the word "recapitulation," which involved a leap

[95] Richard Goldschmidt, *Portraits from Memory: Recollections of a Zoologist* (Seattle: University of Washington Press, 1956), 35.

from superficial resemblance to genetic kinship. Haeckel's already contentious reception combusted most sensationally around his use of images in demonstrating evolution.

Haeckel's popular books introduced a series of illustrations that, like Huxley's and Zallinger's, would become iconic for the theory of evolution. Haeckel's images—which were subsequently reproduced in the works of British and American popularizers, and which occasionally crop up even in contemporary biology textbooks—frequently employed sequences showing physical transformation over time, or suggesting anatomical resemblances among different species. Haeckel's name is deeply associated with sequences displaying, as an illustration of evolutionary development, the growth of different species of embryos. Often he juxtaposed two or more different embryonic sequences, producing a matrix that compared animal embryos at equivalent stages of development. The relation between these embryonic series and the principles of evolution (the gradual modification and differentiation of species as a result of natural selection) constituted Haeckel's "biogenetic law." One iconic illustration, which was originally published in Haeckel's *Anthropogenie* of 1874, compares eight embryological columns over a two-page spread, showing (from left to right) the embryonic stages of a fish, salamander, turtle, chick, pig, cow, rabbit, and human (figure 12). This mosaic diagram demonstrates eight continuous progressions from simple zygotes to increasingly differentiated organisms. But the image also complicates this sense of progression, highlighting how gradually each organism develops its definitive characteristics, and emphasizing the interspecies similarities in the early and intermediate stages. The top row shows four crescent-shaped worms whose formal resemblance is so close that it is impossible (for a layperson, anyway) to draw substantial distinctions, or to guess which species is which.

The illustration contains only the best available samples of these embryonic stages, but their arrangement is loaded with implications.[96] The symmetry seems to require no context or textual support; it is offered as immediate, obvious, and striking. The Darwinian significance imputed to these parallel stages was that each species shares common ancestors, and that the *adult* forms of these ancestors are essentially those of the shared embryonic stages.[97] The late, articulated forms of these organisms branch off from a common primitive *ur*-form, just as their species had at some point branched from a common forebear. Haeckel's biogenetic law is in some sense contained in these comparative images—the idea is inspired by these formal analogies between developing form, and even though its chief claim concerns extinct beings we can never actually behold, it refers only to their outward visible forms, what they would look like if we could see them. Such parallels gave new impetus to evolutionary research, indicating extinct missing links that might yet be recovered from the fossil record. But their value lay in giving (hypothetical) visual presence to a process that otherwise transcended human powers of witnessing. The lost forms of transitional species were preserved in these telltale ontogenetic stages, and to view the unfolding of a given embryo was in effect to replay the tape of species evolution in fast-forward.[98]

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[96] Richards discusses the multiple sources for Haeckel's sequential diagrams, which were generally duplicated from well-known medical textbooks of the era. See Richards, *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought* (Chicago: The University of Chicago Press, 2008), 234-244.

[97] The specific claim that it is the adult stages (not embryonic ones) that are coded into ontogeny is often singled out as recapitulation's crucial fallacy.

[98] This idea of "replaying life's tape" is advanced as a thought experiment by Gould in *Wonderful Life* (48-52). The meaning he gives to it is decidedly different from what Haeckel might have had in mind (had he been familiar with VCRs): that if we could rewind the tape of evolutionary history, reset conditions to some earlier point in time, and then let things unfold again, they would almost certainly play out differently than they happened to the "first" time.

Haeckel was himself a gifted draughtsman, and his imaginative drawings and paintings adorned both his scientific publications as well as his popular volumes.[99] These drawings varied from schematic diagrams, to field sketches, his intricately traced plates of radiolarians, as well as his speculative portrait of a proto-human family huddled stoically beneath a dusky tree. All of these illustrations were full of seemingly gratuitous detail, texture, contour, and color—as in the gnarled branches and rough bark of his phyletic trees (figure 13). The epistemic value of these graphic ornaments is hard to specify, except as outgrowths of a Goethean disposition that valued nature's aesthetic fullness as inseparable from its scientific description. Artistry, it seems, was more than a resource through which to communicate more provocatively the lessons of science; it was rather a force present in nature's own operations, to which the scientist's craft was only more or less faithful—the beautiful essence alluded in the title of Haeckel's late publication, *Art Forms in Nature [Kunstformen der nature]* (1899-1904).

In keeping with this imagistic working process, Haeckel seems at times to have treated his illustrations as self-contained, self-sufficient arguments. Of his sequential illustrations of embryonic development, he insisted that they gave evolution, not just a striking visualization, but its most compelling *proof*. They were in themselves evidence of the truth of Darwinism. This recourse to visual argument also invited fierce criticism. Haeckel's detractors complained that these kinds of similarities were strictly apparent, that the turn from analogies to genealogical links was pure speculation, and that it leapt over considerable gaps in the fossil record. Especially as instruments of popular persuasion, this

[99] Haeckel's artistic prowess has been widely remarked. For a consideration of how his aesthetic and scientific impulses interacted, see Robert Michael Brain, "Protoplasmania: Huxley, Haeckel, and the Vibratory Organism in Late Nineteenth-Century Science and Art," in *The Art of Evolution*, 92-123.

use of images seemed to seduce the reader rather than compel her reason through ample logic and material evidence. In one case, Haeckel stood accused of outright fraud when it was discovered that one of his embryological comparisons had actually reproduced the same figure three times. Beside three plates identified as the fertilized eggs of three different species, Haeckel defied his reader to discriminate among them: "If you compare the egg of the human with those of the ape and the dog, you will not be able to perceive any difference."[100] The challenge, Haeckel's critics contended, revealed the deception at the heart of evolutionary theorizing. Of course no difference could be perceived: the figures were in fact duplicates of one and the same image.

The resulting scandal did much to damage Haeckel's reputation, with one critic characterizing the illustration as "a game of three card Monte with the public and with science."[101] But the error rehearses some rather benign anecdotes concerning the mislabeling of embryo specimens. Charles Darwin recounts in the *Origin* how another naturalist failed to label "two little embryos in spirit," which he subsequently found himself "quite unable to say to what class they belong."[102] Episodes like these confirmed the provocative similarities between embryo forms, which, after all, was precisely the point of Haeckel's infelicitous comparison. In Haeckel's case, however, the damage accrued less from the mistaken labeling than from the kind of work he wanted the figures to perform. The images were

[100] Quoted in Richards, *The Tragic Sense of Life*, 242-3.
[101] Ludwig Rütimeyer, quoted in Richards, *The Tragic Sense of Life*, 243.
[102] Charles Darwin, *The Origin of Species*, 3rd ed. (London: Murray, 1861), 470-1. Quoted in Jane M. Oppenheimer, "An Embryological Enigma in the *Origin of Species*," 234. Oppenheimer points out that Darwin's attribution recapitulates the very kind of mislabeling he is describing. In the first two editions, the anecdote of the omitted labels is attributed to Louis Agassiz, whereas it was in fact taken from von Baer.

offered, not merely as visual aids to bolster an otherwise sound demonstration of interspecies kinship, but as real evidence in favor of that kinship.

Even before Haeckel, images were never accessories in theorizing either evolution or recapitulation. Theories of parallelism emerged as images of fossils and embryos became increasingly familiar items in the collections, museums, and publications of natural history. These archives, along with the means of mechanically reproducing natural likenesses, provided the material and media which made the comparative method viable. Other "genetic modes of thought" had, of course, predated this attention to embryos—for instance the well-traveled notion of the "ages of man," which organized human history through the metaphoric life cycle of infancy, adolescence, maturity, and senescence. What was new at the end of the eighteenth century was, as Temkin puts it, embryology loaning "its concrete image of the ontology of an individual to the other realms."[103] It was the *image* of embryological development that dialectically merged with other conceptions of historical development; it was this image that became an epistemic resource in the emergent biological disciplines. Recapitulation was a theory built upon the scrutiny and comparison of visible forms. It was, in this sense, a theory *of* images—one which gave new weight and new life to visions of embryonic becoming.

In giving such pronounced importance to images of embryogenesis, what, precisely, did theories of recapitulation assert? As we have seen, a number of early Romantics understood the parallels between embryonic stages and fossil organisms as twinned expressions of a deeper formative principle, as "merely modifications of one and the same

[103] Temkin, "German Concepts of Ontogeny and History around 1800," 244.

force."[104] These kinds of theories forge a comparison across radically different scales of time and space, and discover in that comparison a unifying logic to the universe. In the case of later, Haeckelian theories of recapitulation, there is again this confident intermingling of scales, only the logic connecting them has changed. The two series do not simply resemble, mirror, or parallel one another; one of them *recapitulates* the other—though the meaning of this connecting verb can be ambiguous.

In his 1921 critique of such theories, Walter Garstang proposed several possible understandings of the word "recapitulate."[105] In general usage, the word means to "sum up" or repeat, to give a summary or synopsis of something—in this case, a condensed presentation of the phyletic series. The word might also be understood to mean that developing embryos *retrace* the path traversed by their distant (and immediate) ancestors. It suggests, then, a kind of iconic resemblance, a short-hand retelling of a selected strand of evolutionary history. Perhaps it suggests a ritual pilgrimage, a re-enactment. The stages of embryology and evolution in some sense "correspond." In Haeckel's formulation of the biogenetic law, the linkage becomes explicitly one of causation. Ontogeny resembles phylogeny because phylogeny has *caused* ontogeny.[106] The embryological stages of development look like extinct, primordial forebears because modern organisms have evolved from them, and because the mechanism of evolution has preserved this ancestry in the

[104] Blumenbach, quoted in Richards, *The Romantic Conception of Life*, 219.
[105] Walter Garstang, "The Theory of Recapitulation: A Critical Re-Statement of the Biogenetic Law," *Linnaean Journal of Zoology* 35 (1921): 81-101.
[106] Garstang counters that it would be more accurate to reverse this equation: that, contra Haeckel, ontogeny causes phylogeny. The insight this summarizes is that an organism should be identified, not with a single icon of its adult form, but with the outward and inward changes it undergoes over an entire lifetime, from embryo to infant to adult to death. Phylogeny, in this light, is rightly seen as a sequence, not of static forms, but of dynamic life cycles—for the course of an organism's life (up to the act of reproduction) is selected for in the Darwinian struggle for survival, not just its mature phenotype.

transitional forms assumed by the developing fetus. Embryology is a record of transmutation, it has encoded ancestral memory in the unconscious unfolding of prenatal form.[107] As a visible sign, the embryological series must be construed as an imprint, a trace, a residue—an index.[108] And this indexical status is precisely what, for Haeckel, makes embryological figures such important resources in theorizing evolution. It is what makes them, not just illustrations, but visible evidence—vivid embodiments of a process whose products are everywhere, but whose workings are always beyond the scope of human witnessing. Recapitulation, we might say, makes the ontogenetic series a kind of photograph—at once an icon of evolutionary transformation (its visible forms resembling significant milestones in the phyletic series), as well as an index of it (having been caused and formed by those same evolutionary determinants). The embryonic series is made to stand as evidence in the same ways that, in the latter half of the nineteenth century, photographs were—as an incarnate residue of a past event, a "mirror with a memory."[109]

What made Haeckel's version of recapitulation appealing, then, was its status as a visible icon of evolution—making the known stages of an embryo's development represent evolution in action—as well as a spectacular form of evidence. This link between embryology and transmutation, Richards argues, was formative in the development of Darwinian evolution as a theory. Etymologically, "evolution" was originally a term in eighteenth century embryology, denoting preformationism—a theory of inheritance and generation, according to which the entire organism was contained, in miniature, within the

[107] Brain notes that Haeckel was influenced by Ewald Hering's *Memory as a Universal Function of Organized Matter*. "Protoplasmania," 96-7.
[108] The notion of ontogeny as an "imprint" of phylogeny is discussed in Nyhart, *Biology Takes Form*, 134.
[109] "A mirror with a memory" was how Oliver Wendell Holmes famously described photography in an 1859 article. "The Stereoscope and the Stereograph," *The Atlantic* (June, 1859). Reprinted in Alan Trachtenberg, ed., *Classic Essays on Photography* (New Haven, CT: Leete's Island Books, 1980), 71-82.

germ of its mother or father, and then *evolved* in utero. By gradual turns the word was extended to apply to species transmutation, to which, following Darwin, it referred exclusively in English.[110] Recapitulation also addressed the need to make meaningful connections between phenomena of radically different scales. In early accounts of parallelism, the formation of the universe, the planet, its strata and species, and finally the individual organism—all expressed, in their distinct tempi, some single force, law, or principle. Those phenomena that were nearer to daily experience, then, provided a lens or heuristic through which to comprehend those that were vaster, more unapproachable, or more deeply buried in the past. Perceiving parallels allowed the invisible intelligence governing the cosmos to be knowable, visible, through striking correspondences.

These shifts of scale, or translations between them, are still operative in Haeckel's biogenetic law, even though the nature of the connections has changed. Ontogeny, in this context, is not just a metaphor through which to imagine evolution: it is a live manifestation of it, even as it signals evolution's grander and more distant machinations. Yet it is still a visual principle that expresses a total worldview, one organized by the law of natural selection. For its German adherents, and perhaps for Darwin himself, evolution often possessed a kind of encompassing intelligence and *telos*—an aesthetic appeal that, to a Romantic sensibility, ensured the common source of organic form and humane beauty.[111] Haeckel used recapitulation to introduce other shifts of scale—proposing, for instance, to understand species as organisms at a grander level, with their own life cycles from

[110] Richards, *The Meaning of Evolution*. See also Peter J. Bowler, "The Changing Meaning of 'Evolution'," *Journal of the History of Ideas* 36, no. 1 (1975): 95-114. Jane Oppenheimer notes that in German the term *Entwickelungsgeschichte* continued, well after Darwin and into the twentieth century, to refer both to "the development of the individual and that of the race." Oppenheimer, "Embryology and Evolution," 206.
[111] See Richards's treatment of "Darwin's Romantic Biology" in *The Romantic Conception of Life*, 514-554.

emergence to extinction, with their own powers of branching reproduction, and so on.[112] But its core analogy also pointed toward a more intimate accommodation between the essential force of evolution and our own finite organs of perception.

As a theory, Darwinian evolution (like some of its precursor theories of species transmutation) returned human beings to the wilds of the animal kingdom. But the mechanism that explained this heretical inclusion was one that could only ever be inferred, never actually witnessed with our finite senses or from our finite emplacement in time and space. With recapitulation and the biogenetic law, evolution was finally made present—as a dynamic process, and in the flesh. It occupied a transitional moment between reading evolution through its signs (fossils, strata, the continuous system of extant organisms, and so on), and actually seeing it as an unfolding process. We can appreciate the biogenetic law as a way to manage the dialectic between those forces we know with our senses, and those we know only by reputation. It provides us with a picture that is not just "like" the process of evolution, but which, like a photograph, resembles its referent *because* it has been formed by it. Haeckel's principle sprang from an epistemological tradition that valued analogies, correspondences, and affinities as lighting a path to valid knowledge of nature. Under this speculative law, ontogeny encapsulates evolution, indexes it. The developing embryo gives us the movements of evolution itself.

Having said so much about the dynamism of embryology, it needs to be recalled that no scientists of the nineteenth century had actually observed an embryo developing in real

[112] See Nyhart, *Biology Takes Form*, 133. "The evolution of the animal kingdom was analogous to individual development not just because the laws of development were the same, but also because the animal kingdom itself was a form of individual." I return, in chapter 4, to consider these sorts of scale-shifting analogies between organisms, communal "superorganisms," and human societies more deeply.

time, or grasped it as a moving image. It would require another chapter (probably more) to summarize the instruments and techniques that gradually brought to light the sequential stages of an embryo's development.[113] The language that described these early images was anchored to the impression of an illicit view—that human eyes (a medical gaze that epitomizes the "male gaze") could inspect a process that always transpired out of view, within a maternal body.[114] This invisibility was at first a matter of the obscurity of the uterus—which in turn made the agency of generation seem "enveloped in the most profound and most hopeless obscurity."[115] As techniques were perfected for taking samples and slices of aborted embryos, they worked to reveal this interior world of development—pointedly, by abstracting the embryo from its encasing body (whether uterus or shell) and from other extraneous material (the amniotic sac, the umbilical cord, the mother). Yet for all this technologically penetrating vision, the embryo's continuous growth remained out of reach, reconstructed and animated only in the mind's eye. When embryogenesis and other budding phenomena were finally animated decades later, they were greeted with similar exclamations of a phenomenon newly unveiled.

Commenting in retrospect on the visual sensibility expressed by various notions of parallelism, modern historians often invoke the language and paradigm of cinema. Garstang, for instance, cautions that "Ontogeny is not an animated cinema show of ancestral portraits"—insinuating that this filmic analogy approximates how Haeckel and his followers

[113] Some of these are discussed by Oliver Gaycken in his paper, "Cinema's Plasticity: The Embryological Series and Animation," paper delivered at the Annual Meeting of the Society for Cinema and Media Studies, Atlanta, GA, March 30-April 3, 2016.
[114] For a deeper and more extensive treatment of gender and medical imagery, see Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis: University of Minnesota Press, 1995).
[115] This is from an entry for "Generation" in the 1842 edition of the *Encyclopedia Britannica*. Quoted in Oppenheimer, "Embryology and Evolution," 209.

saw embryogenesis.[116] Timothy Lenoir hits more precisely on the spirit of these tentatively moving images when he describes the teaching laboratory of Karl Friedrich Burdach. The morphologist arranged the items in his display cases and examining rooms in continuous series, thereby revealing "the systematic interconnections between all the various elements" of life, such that they "unfold almost as if one were to have before him a time-lapse film of embryological development."[117] As the examples analyzed in this chapter reflect, evolutionary processes were envisioned in these years through various kinds of sequential images. For historians, it is tempting to see these serial images of embryos, fossils, and evolutionary milestones as so many photographic cells awaiting animation. Biologists and evolutionists of the early nineteenth century had never seen such moving pictures, but this comparison to animation may not be inappropriate. If, as Temkin put it, embryology introduced a vivid image that gave new life and new figural contours to existing ideas about ontogeny, this image's true novelty lay in it being an image of *movement*. It suggested a continuous series of transitional forms, which might effectively plug the gaps and intervals in the fossil record and in the plenum of organic lifeforms. Even without the element of cinematic movement, embryogenesis animated the thought of evolution and its formative analogies in other ways. As Burdach described it, the sight of these progressive stages would spark an experience in which "the living forms and their necessary interconnections swim before [one's] soul."[118] That these interconnections would spring to life within a human consciousness was not a case of the Kantian ego projecting its own coherence onto

[116] Garstang, "The Theory of Recapitulation," 100.
[117] Timothy Lenoir, "Morphotypes and the Historical-Genetic Method in Romantic Biology," *Romanticism and the Sciences*, eds. Andrew Cunningham and Nicholas Jardine (New York: Cambridge University Press, 1991), 127.
[118] Quoted in Lenoir, "Morphotypes and the Historical-Genetic Method," 127.

indifferent, amorphous reality. Rather, this psychic animation fulfilled the condition sought in Schelling's philosophy of nature—the world projecting its own vital image onto the screen of our minds, rendering human consciousness the instrument through which nature knows itself.[119]

We are within our rights in relating this visual impulse to figures of cinematic movement. The imagined spectacle of embryological development functioned like a photograph—it illustrated evolutionary transmutation while also providing an evidentiary record of it, a primordial, plastic memory. Conversely, this earlier philosophy of life tells us something about the nature and power of filmic animation, and the kind epistemological framework to which time-lapse photography (real, or anticipated) putatively belonged. Here, finally, were evolutionary movements—blossoming flowers, developing embryos, dividing cells—that were really visible. But the value of this stunning visibility was also measured by the scales of unwitnessed becoming that it gestured toward: the transmutation of species, the recession of continents, the very formation of the universe out of nebular chaos. Informed by these traditions of sequential imaging, time-lapse photography can be appreciated, not just as visualizing processes normally imperceptible; rather, and more profoundly, it takes its place among these other visual, aesthetic strategies for mediating the tempi of nature—for making visible movements represent and correspond to others we only imagine; for making aesthetic splendor the proof of cosmic interconnection; and for treating movement, not just as an

[119] Burdach writes: "we are not blind products, rather being is an object for us, and to us the world comes to self-consciousness, to self-intuition" (quoted in Lenoir, "Morphotypes and the Historical-Genetic Method," 126). Compare this to Schelling: "In reason, that eternal identity is itself both the knower and the known. It is not I who recognizes this identity, but the eternal recognizes itself, and I am merely its instrument" (quoted in Richards, *Romantic Conception of Life*, 183).

added dimension or a special effect, but as the fundamental filament binding together the phenomena of life, present and indexed on the strip of exposed film.

Conclusion: Screening/Sensing Life

To the expansive assemblage of scientific devices and iconographies that make up (along with various toys, performance spaces, technologies, and media) the "prehistory" of cinema, it would be possible to add these other examples of sequential images. We might, toward this end, examine how they (and the evolutionary research programs to which they belonged) contributed to the physiological and psychological research that laid the groundwork for moving images, and how they shaped the iconographic protocols of Marey and Muybridge. The intersection of Marey's extensive graphical experiments with the evolutionary research of Ernst Haeckel has already been noted,[120] and it was out of this mutual concern with the corporeal pulse and plasticity of life that the work of chronophotography emerged. A fuller treatment of the intersections of nineteenth-century evolutionary research with "the cinematic" remains to be written.[121]

My emphasis in this chapter has been upon a narrow sampling of the myriad sequential strategies that paved the way for evolutionary theory, and which were later adopted in presenting evolutionary ideas to a non-specialist audience. These contexts of research and education raise questions about the epistemic value of these kinds of images,

[120] Robert Michael Brain, "Protoplasmania."
[121] Two examples that begin to digest this relationship bear mentioning: Oliver Gaycken, "Early Cinema and Evolution," in *Evolution and Victorian Culture*, eds. Bernard Lightman and Bennett Zon (New York: Cambridge University Press, 2014): 94-120; and Barbara Creed, *Darwin's Screens: Evolutionary Aesthetics, Time and Sexual Display in the Cinema* (Melbourne: Melbourne University Press, 2009).

and the relation between knowledge, evidence, and aesthetics more broadly. Along these lines, I have entertained the thesis that there is an abiding affinity between photography and these imaging techniques, in that they model epistemology in ways that are roughly isomorphic with photography. They work upon the same axes of visibility and invisibility, iconicity and indexicality, evidence and illustration, which structured (and in many ways continue to structure) the epistemic discourse around photographs. Even when these sequences did not employ photographic methods *per se*, they emerged out of a common historical/scientific/philosophical context, and so these affinities are more than superficial, or strictly metaphoric.

These graphic methods—the "March of Progress" which continues to evolve and proliferate in popular culture; the fossil sequences which naturalized both the ontogeny of creatural images and the order of their arrangement; the diverse fetal comparisons that expressed the doctrine of recapitulation and thereby "shadowed forth" the course of species transmutation[122]—belong, like photographs, to a scientific visual culture that was constantly inventing new means to inspect, surveil, and track the activities of life. "Life," to these emergent biological disciplines, might be identified with the jagged graphs describing an amphibian's heart rate; it might be a cross-section depicting one or more states of embryonic development; or it might be the swarming commotion of cells upon a microscopic slide. The vital movements of evolutionary change were conceived in conjunction with these images and media, and gave these local varieties of liveliness an encompassing, unifying framework. Naturally, evolutionists drew on these iconic and graphic resources to visualize evolution,

[122] Darwin had mused that an image of embryonic development would "shadow forth" a creature's ancestral history.

even as evolutionary transmutation continually proved itself a stubbornly *in*visible phenomenon.

My focus has been on three examples (representing broader genres) of sequential images which seek not so much to map evolutionary filiations (as in a diagram of a phyletic tree), or to communicate them or digest their core meaning, as to give them visual *presence*. They sought, in some sense, to imprint evolution in the way a photograph imprints a physical object—the way a fossil does, or the way Haeckel believed a gestating embryo did—in order to retrace the changing morphologies of different species over inconceivable stretches of time. Temkin's phrase—that embryology "loaned a concrete image" to philosophies of generation—captures the spirit in which photography and fossils may have loaned mutually sustaining notions of "imprinting" to one another, and how cinema retrojects a sense of virtual movement into these diverse cases of sequential picturing. At the same time, we should consider these influences dialectically: to contemplate how the revelatory/authenticating pragmatics of photographs (and films) were informed by these affinities with fossils, progressive "marches," and visions of embryological transformation—forms of media with which, after all, they emerged in concert. My closing thought for this chapter, then, is that we place time-lapse photography at the interface between these sequential strategies and the epistemic model of photography.

In my reading, the notion of recapitulation depends on an anticipatory envisioning of time-lapse movement. It begins by envisioning embryogenesis transpiring before our eyes, and projects this imagined spectacle onto the phyletic series, giving us some inkling of what it would be like, not just to know evolution through its fossilized traces and vestigial remnants, but to catch it in the act. In approaching an animated vision of an invisibly gradual

process (ontogeny), recapitulation offers us an intriguing presentiment of time-lapse photography. It also, more significantly, helps us think about the epistemological value of time-lapse images. In addition to technically telescoping time, so that the gradual progress of gestation elapses before the mind's eye as a continuous movement, the time-lapse vision of recapitulation conceives this motion as a condensation of even more gradual, more radically inaccessible phenomena. Garstang alludes to this when he refers to how the biogenetic law positions embryogenesis as telescoping phylogenesis (though he does not acknowledge how the vividness of embryogenesis depends on a similar modulation of temporalities). This triadic modulation of temporal registers depends on the capacity of one segment of sensational movement to render, and in some sense actually capture, several other temporalities. I would suggest that similar work is often performed by subsequent examples of time-lapse photography: that they actually capture and embody forms of invisible movement; but that the movements we thereby behold tend to evoke, or imaginatively correspond to, other forms of analogous movement that we cannot hope to capture on film.

Returning to the passage by Ernst Mach with which I began this chapter, we can shed new light on the character of the examples he envisions. The gestation of an embryo, the ancestral limbs of the phylogenetic tree, the arc of a human life from cradle to grave: these are not arbitrarily selected examples of movements we would like to see but currently cannot. These are all examples of evolution in its fully complex sense: each case can be denoted by the word evolution, or development; and each of them determines and expresses the others. What would be accomplished by Mach's "series of magic lantern projections" is, of course, that these inferred aspects of evolution would become available to the senses. In so doing,

such images would also begin to express the *unity* of these different spheres of becoming, and restore them to our sensory universe.

This is the kind of significance that is at stake in the language of recapitulation; and it is worth noting that Mach would have been no stranger to these ideas. By the time of Mach's article, Haeckel's biogenetic law was widely circulated and hotly debated among the reading public in the West, and especially among scientists. And while Mach was an outspoken opponent of metaphysics and all things Kantian, he was a personal friend of Ernst Haeckel and made Darwinism central to his philosophy of science.[123] The Mach we find in his influential writings on sensation is a man who conceives science as system for unifying and enriching our interactions with accessible phenomena. So while Mach, like later practitioners of time-lapse photography, was vague on the *scientific* value that time-lapse techniques might have, it is clear that such moving images would contribute to this second-order mission of unifying experience and expressing the unity of earthly phenomena. They would not so much reveal the truth of evolution, or animate its ideas once and for all; these time-lapse images would join fossils, embryos, and the particular ways in which we animate them, in making these forms of organic movement visible, and in enabling them to bear new kinds of significance.

Figures:

[123] Erich Becher, "The Philosophical Views of Ernst Mach," *The Philosophical Review* 14, no. 5 (1905): 535-562.

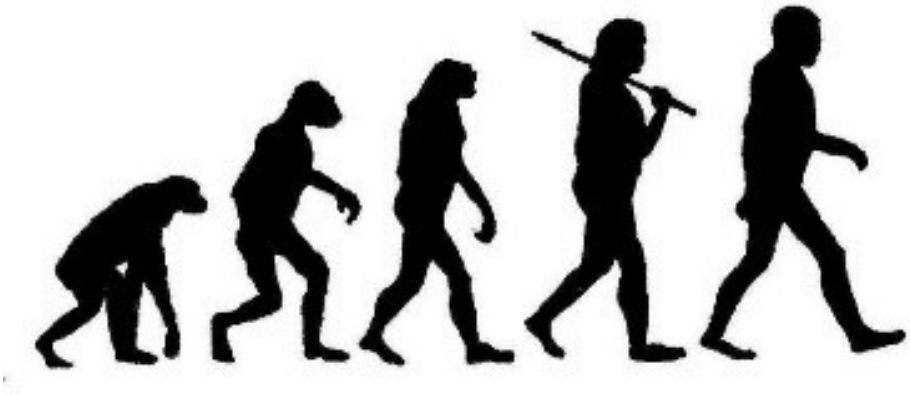

Figure 1: A typical variant on the March of Progress iconography.

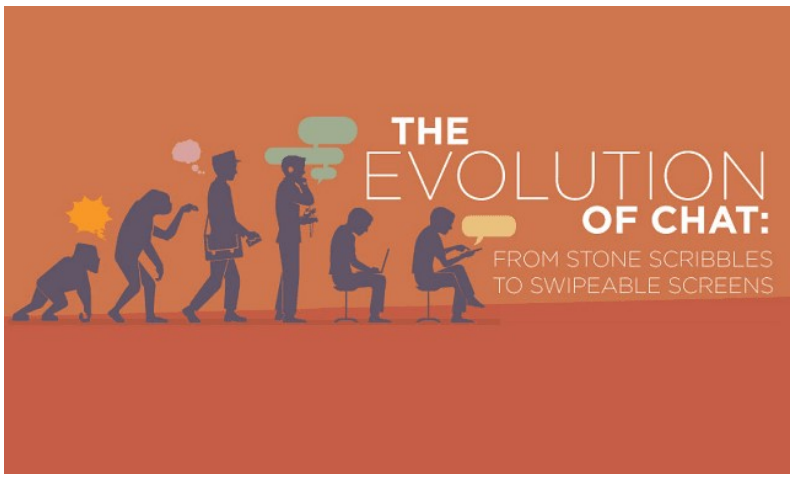

Figure 2: "The Evolution of Chat": infographic adapting March of Progress iconography to track the development of personal communications technology. Original from: http://www.whoishostingthis.com/blog/2014/09/17/evolution-of-chat/

Figure 3: “The evolution of iMac.” 2012 Print advertisement for Apple computers.

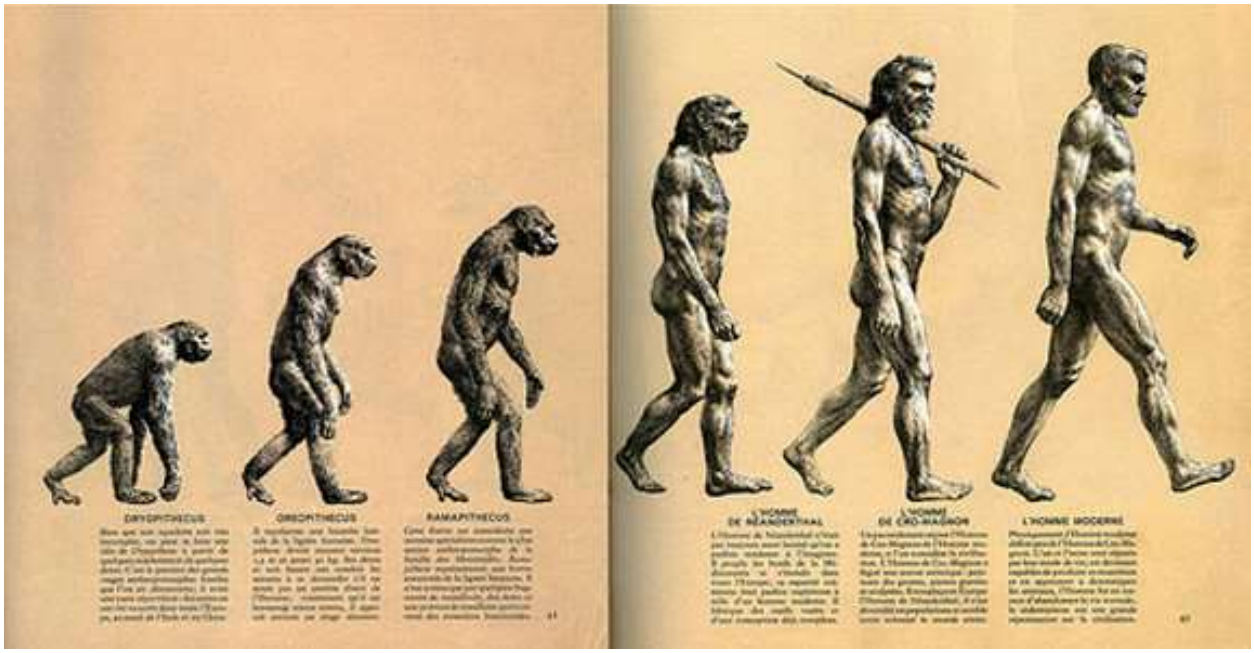

Figure 4a: Rudolph Zallinger’s original “March of Progress” illustration, from F. Clark Howell et al., *Early Man* (New York: Time Incorporated, 1965): 41-45.

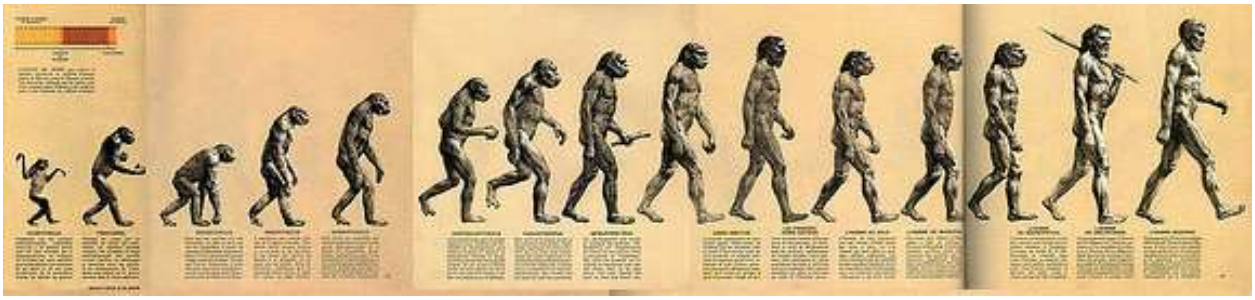

Figure 4b: The full, fold-out version of Zallinger’s illustration.

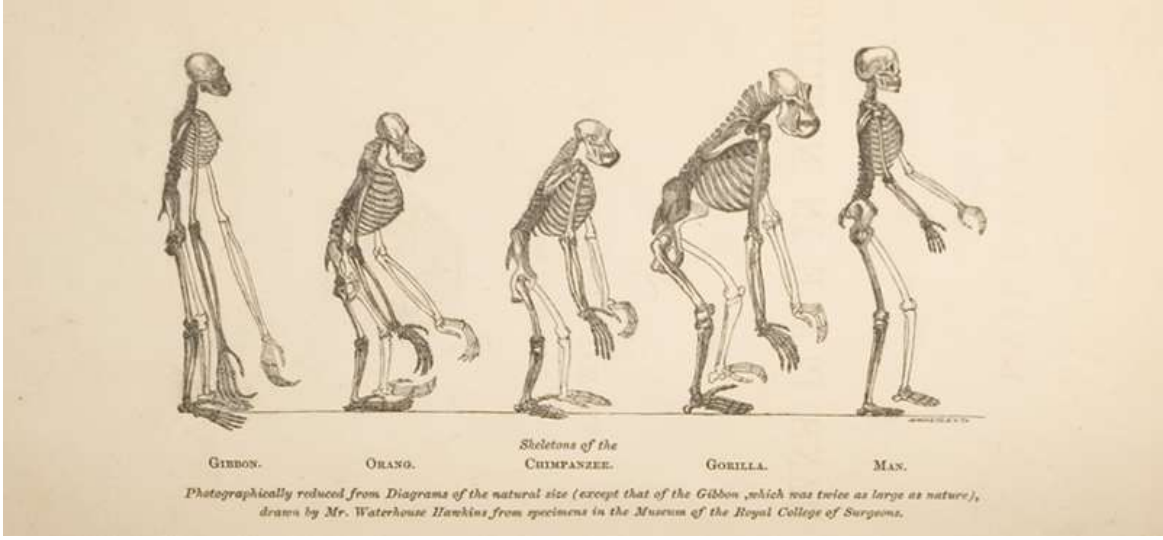

Figure 5: Frontispiece to T.H. Huxley, *Evidence as to Man's Place in Nature*. The lower caption reads: "Photographically reduced from Diagrams of the natural size (except that of the Gibbon, which was twice as large as nature), drawn by Mr. Waterhouse Hawkins from specimens in the Museum of the Royal College of Surgeons."

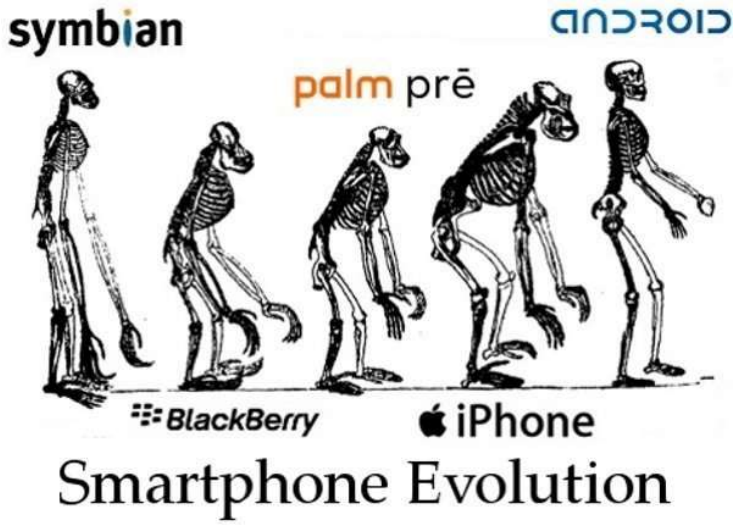

Figure 6: Huxley's frontispiece adapted to demonstrate the relative advancement of smartphone technologies.

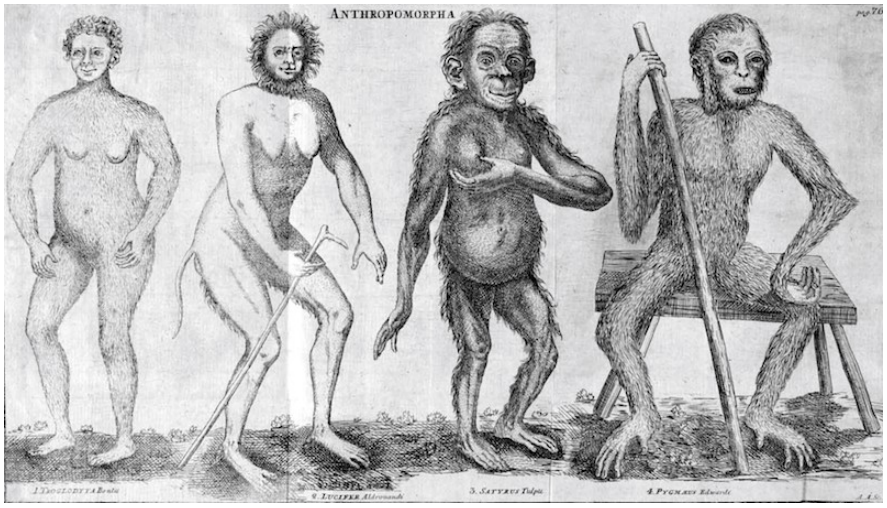

Figure 7: Linnaeus's "Family of Man." Reproduced in Huxley, *Man's Place in Nature*, 22.

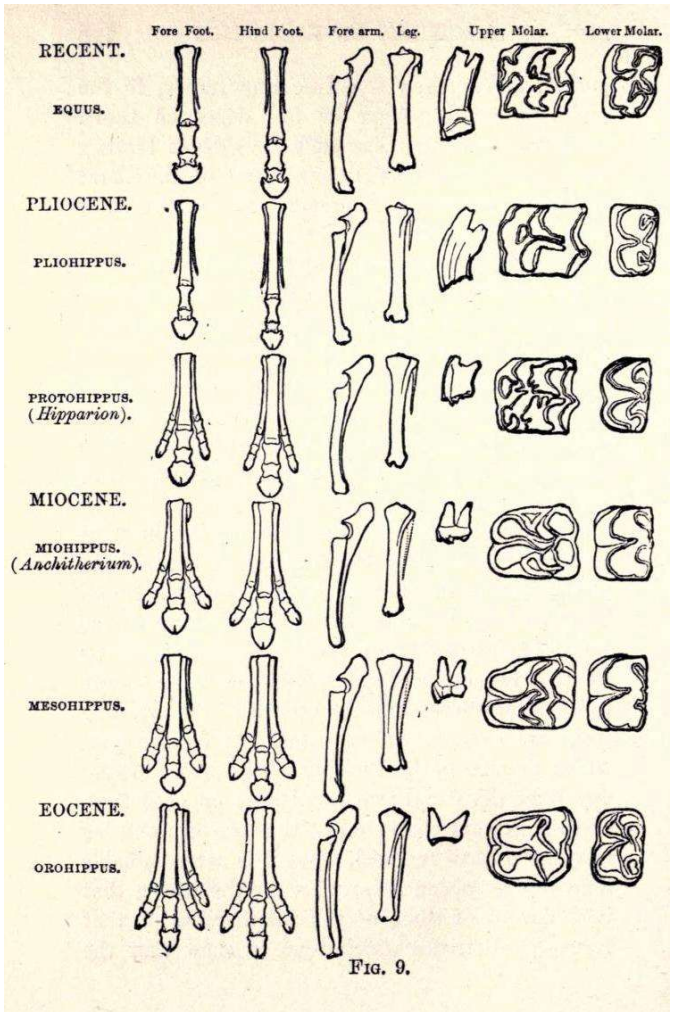

FIG. 9.

Figure 8: Evolution of the horse, as evident in seven homologous bone structures. From T. H. Huxley's lecture "The Demonstrative Evidence of Evolution," slide prepared by Othniel Charles Marsh.

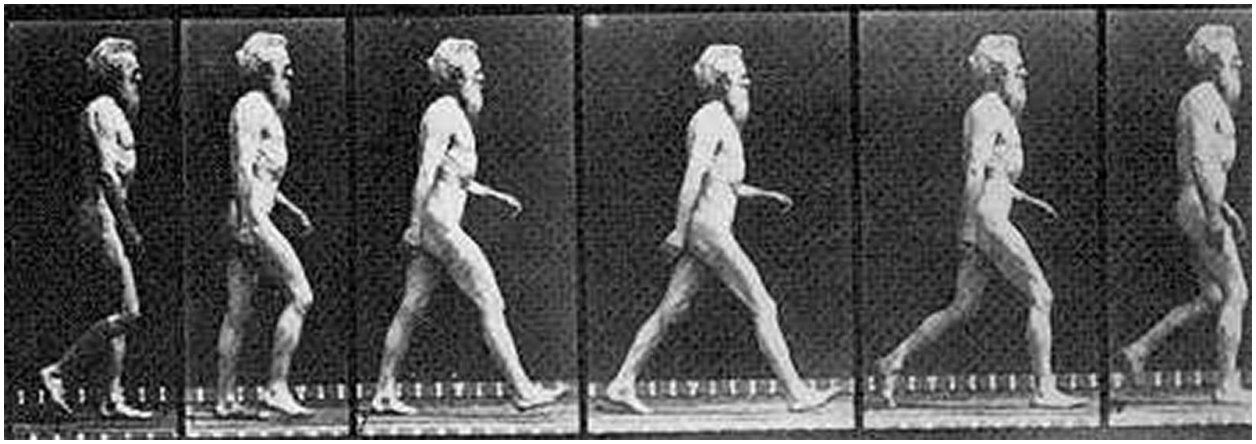

Figure 9: Eadweard Muybridge, from *Human Locomotion*.

Figure 10: Daguerréotype "Coquillages [Shells]", 1839, Louis Jacques Mandé Daguerre © Musée des arts et métiers-Cnam.

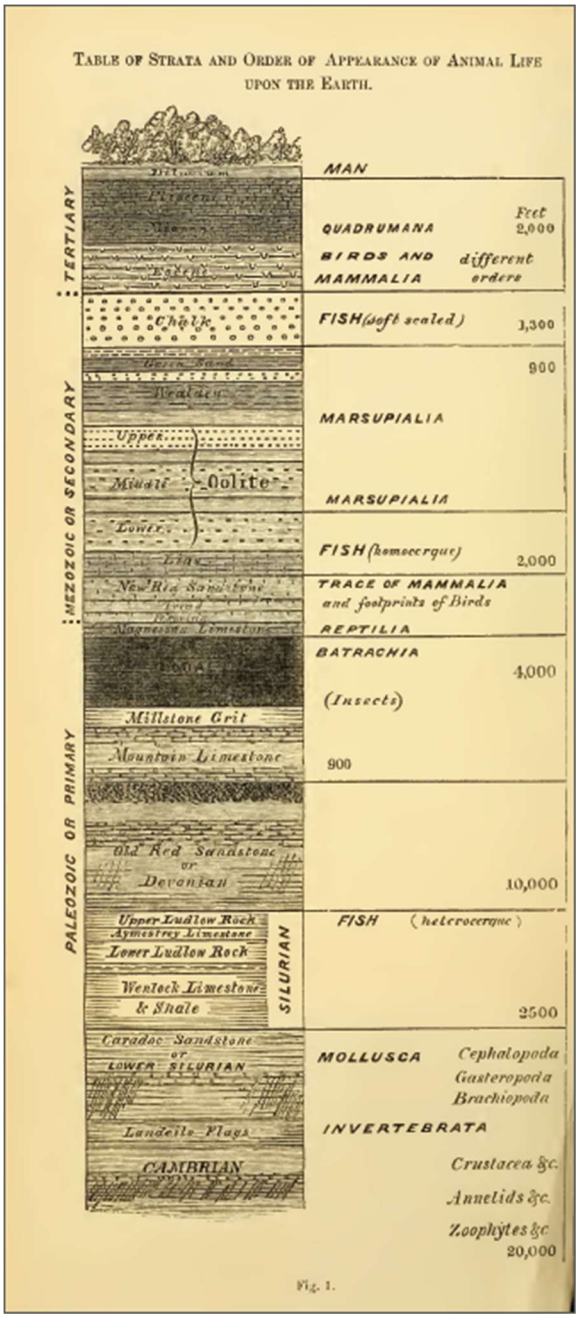

Figure 11: "Table of Strata and Order of Appearance of Animal Life upon the Earth," diagram from Richard Owen, *Paeleontology* (1860).

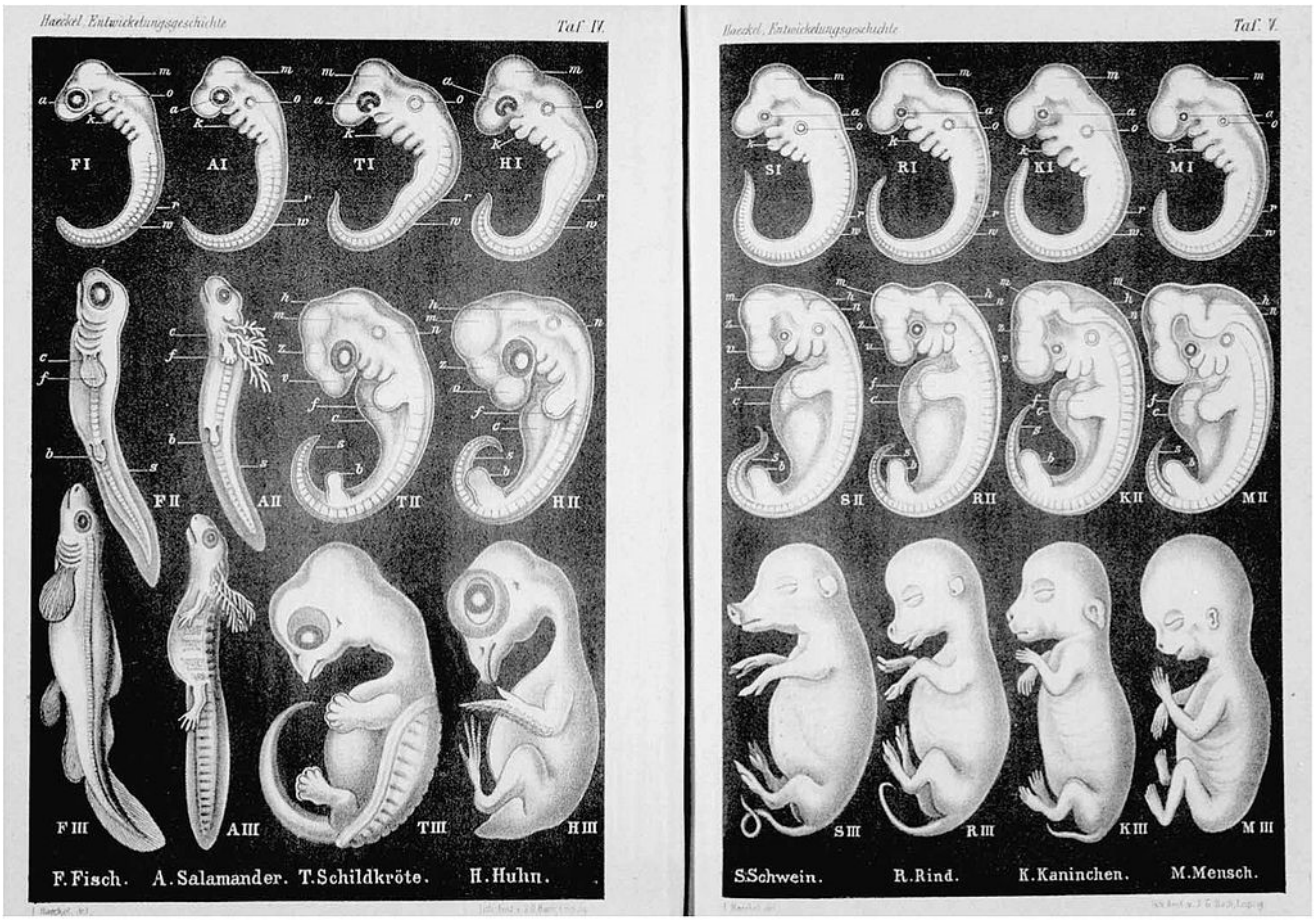

Figure 12: Embryological development of fish, salamander, turtle, chick, pig, cow, rabbit, and human. From Ernst Haeckel, *Anthropogonie* (1874).

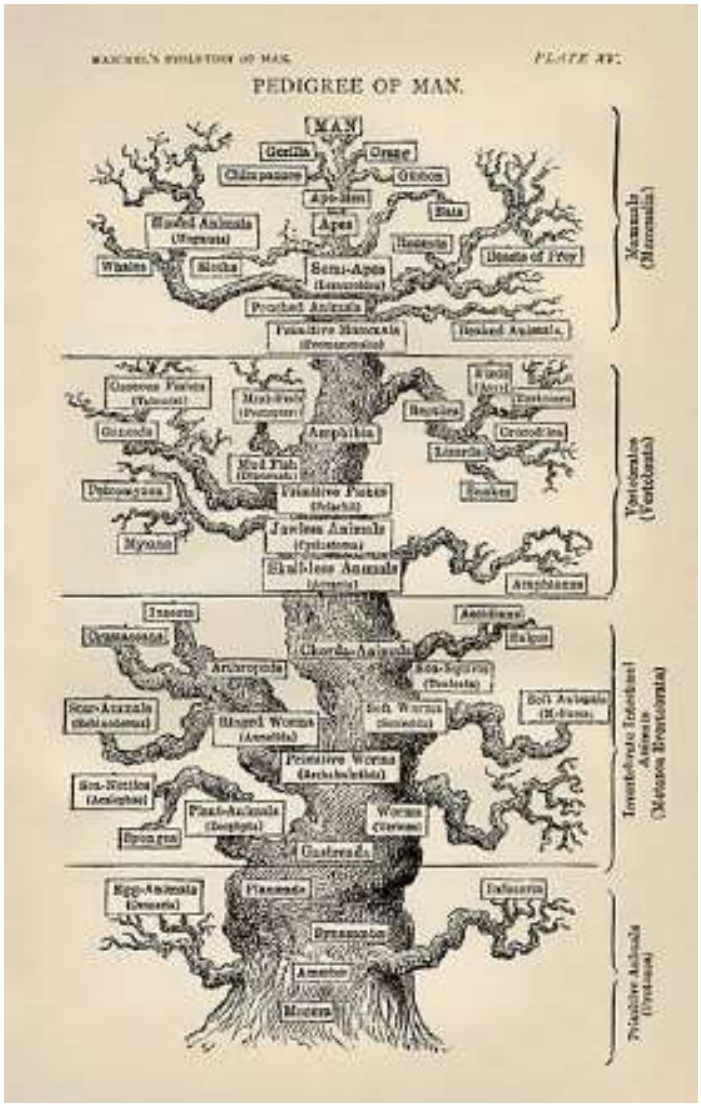

Figure 13: Ernst Haeckel's "Pedigree of Man"—one of several similar "tree of life" diagrams appearing in the English version of Haeckel's *The Evolution of Man* (1879).

Chapter 3:

Clockwork Gardens: The Mechanics of Photography and the Intelligent Powers of Plants

The Power of Plants is a short educational film produced in 1951 for the television series *John Kieran's Kaleidoscope*. Framed by an awkwardly staged, "casual" conversation between John Kieran ("the man with the encyclopedic mind") and his everyman neighbor, the film presents a series of laboratory experiments that showcase various forms of strength you never knew plants possessed.[1] One demonstration involves pea pods that have been planted in soil enclosed by glass bottles. We might innocently assume that these spindly buds, even as a collective body, will find their growth hemmed in by the rigid, glass enclosure—but our ignorance is soon corrected. The time-lapse footage shows the peas growing and rising and beginning to press against the interior walls of the bottles. The bottles quickly prove no match for their riotous inhabitants, and one by one they "shatter,"[2] allowing the beans to grow unencumbered. Another set-up shows lilies of the valley being planted in pots and covered with five layers of tin foil. Once these botanic subjects are installed, a time-lapse sequence follows, showing how the shooting growth of these stalks makes the foil swell like a tin of heating popcorn, until a collection of spears neatly pokes

[1] The film can be viewed online via the Internet Archive: https://archive.org/details/PowerOfPlants. Last accessed February 18, 2018.

[2] That is, we see the intact bottles give way to progressively cracked and broken ones, as in a series of jump cuts. The real-time shattering is of course too quick to be registered by the successive frames of the time-lapse film.

through the foil, rising upward in thickening spears and spreading their "delicate" blooms. Others show a thick swath of sprouts rising in unison against a thick plate glass lid, which they easily lift, like an army of ants, before casting the plate aside and wiggling upward as if in delight at their freedom. The experiment is repeated with iron weights added to the top of the glass—but to no avail. Again, like indefatigable strongmen, these sprouts lift the glass inch by inch until the weights slide off, they slough off the glass plate, and stretch skyward in relief.

These time-lapse demonstrations suggest an ambiguous interplay of human control and organic vitality. Each feat of strength is highly contrived, testifying to the ingenuity of the experimenters in designing the set-up and determining how best to isolate and dramatize the phenomena of interest. To the extent that Nature's power is on display, it has been carefully framed, measured, and sampled by the scientists and by the time-lapse photographers. And yet, each of these contrived scenario shows the plants defying modern techniques of containment. We witness a dialectical contest of wills, the scientist opposing the plants' growth with the fruits of industrial manufacture—blown glass, tin foil, copper wire—while the plants stubbornly pursue their own life pattern, literally pushing against and bursting through these artificial barriers. On the one side, we acknowledge the technical ingenuity used to frame and record these plants in their astonishing efforts. On the other side, we take strange delight in the autonomy of the plants themselves—their commitment to innate impulses, their cooperative action, their unthinking intelligence, their irrepressible vibrancy.

We should acknowledge that this impression of independent action on the plants' part is itself highly contrived: it is an effect the filmmakers have, through ingenious technical

machinations, designed upon us; it is the rhetorical point of these experiments. But the questions I want to extract from this appealing film concern the relationship between the forms of automatic activity it represents, and those embodied in its technical basis. The time-lapse images confront us with the autonomous and self-sustaining movements of the plants, their capacity to act without human guidance, their power even to defy artificial constraints. What enables these same images, however, are the component technologies of the time-lapse apparatus—the combination of film equipment and instruments for maintaining light, camera position, and frame rate over the days in which various botanic behaviors are registered. Like the plants and like photographic techniques in general, this recording ensemble also acts autonomously, in that it dramatically curtails any reliance on camera operators once the ensemble has been set up and calibrated. What significance, then, do these two interlocked examples of autonomous action—these two forms of *automatism*—have for us? What meanings do we attach to the fact that plants grow and flower and flourish, or to the more general fact that they are capable of movement, or to the impression that we are witnesses to these movements? How are these facts and ideas themselves colored by the medium through which we know and behold them—by, that is, the mechanical automatism of the time-lapse apparatus? Judged independently of the images and impressions it engenders, what do we make of the apparatus itself? What values and worldviews are embedded in this technology, and how do these values influence the aesthetic currency of its products?

These questions relate to, and in some sense modify, a basic question about film as an artistic medium: how its mechanical bases enable or constrain its capacity to foster creative shaping by human agents. This question has been recurrent in theories of film and photography, and was especially poignant in the years in which these media first emerged. It

is a question that is both dramatized and destabilized by the genre of time-lapse films depicting the growth of plants. Time-lapse techniques, considered in themselves, intensify the automatic, machinic attributes that even the earliest theorists associated with film technology. Telescoping cinematic time generally calls for unmanned cameras and clockwork contraptions for regulating frame rate, and the resulting spectatorial effect, especially in portraying inorganic phenomena, often suggests a machinic gaze upon implacable, mechanically unfolding processes. And yet, as *The Power of Plants* illustrates, plant-growth films married these mechanical determinants to self-evolving phenomena of a different nature. Plants, especially in their power to grow and flourish untended, had long figured in aesthetics as counterfigures to the predictable and reproductive logics of clocks and clockwork machines. As recurring subjects portrayed by early photographers, intriguing comparisons could be drawn between the formative powers of plants—their private unconscious intelligence—and those of the photographic medium portraying them. Plant-growth films, like earlier nineteenth-century encounters of botany and photography, added a new dimension to the mediatic lives of plants. Singling out and resynthesizing the vagaries of vegetative movement, these motion pictures authorized the impression that plants were uncannily purposeful beings. They therefore expanded and enriched the range of significance that could be attached to these lifeforms, enhancing their capacity to excite new associations, accommodate new concepts, and suggest new metaphoric structures. For all that these films were highly generic and impersonal, they could nevertheless inspire new insights in various sectors—including, it turns out, new theoretical perspectives on the automatic habits and organic, instinctive, productive resources of the film medium itself.

The chapter approaches this dialectic of mechanical technics and organic creativity from two alternative vantages. First, I examine how film critics and theorists of the 1910s framed and evaluated the new medium's relation to manufacture and other dominant icons of mechanism—how they felt this as a potential constraint on the photoplay's capacity to convey artistic statements, and how they articulated what they saw as the medium's distinctive creative avenues. These polemic defenses of film often sought solid ground in petrified aesthetic philosophies, but they also show how aesthetic attention to cinema could double as an inquiry into mechanization writ large—a critical function which was rhetorically foreshadowed in nineteenth-century disputes over photography. In relation to these lines of analysis, time-lapse photography can be taken as example and emblem—a moving image technique especially reliant on clockwork automatisms and apt to show external forces, whether natural or industrial, as uniformly mechanical, efficient, and inevitable in their progress.

Early twentieth-century concerns about the meaning of cinema in relation to the "machine age" have telling precursors in the preceding centuries, and the chapter continues by tracing some of these epistemic roots, especially the complex and shifting meaning of "mechanism" in connection with mechanist philosophies and their varied antagonists. The dialectics of mechanism were very much in play when nineteenth-century critics of photography voiced their hopes and concerns about this increasingly prevalent pictorial medium. And yet, if we focus more narrowly on the years immediately following photography's invention, and examine the strange rapport between photography and botany during this period, we get a different picture of the cultural understanding of this emergent medium. I focus especially on how photograms of botanical specimens—photographs made

through contact printing, without the optical mediation of the camera—figure the creative collusion of plant energies and photographic process. These images give graphic significance to the quality of contact between medium and specimen, making *contact* itself a causal force through which the creative potentialities of plants and photographs correspond. The organic creativity of plants was also, during the nineteenth century, conceived through scientific and aesthetic understandings of their powers of movement. What Goethe thought of as the "metamorphosis" of plants, and what Gustav Theodor Fechner expressed as their "soul life," was a phenomenon demanding sublime powers of observation, and which ascribed intelligence (or something like it) to vegetative lifeforms. Turning to plant-growth films of the 1890s through 1920s, I assess to what extent these scientific motion pictures satisfied the Goethean ideal of immediate and holistic perception, and how they spoke to Fechner's controversial thesis of plant mentation. If these films succeeded at giving perceptual life to the physiological movements of plants, they also gave them conceptual depth, inspiring new sorts of analogies and associations besides the ones that had long flourished in poetry. Ultimately these new and dynamic associations fed back into theoretical writing on the cinema: especially for French theorists of the silent era, cinema was most itself when it effortlessly revealed the symbolic microcosm of plant behavior; its automatism was by the same token linked to the unconscious creativity of organic phenomena, as opposed to the mindless reproduction of industrial machines.

Early Conceptions of Film and Mechanism

Theorizing motion pictures, especially in the first decades of the twentieth century, first found its feet in a milieu of highbrow hostility. Legitimacy for the new medium had, accordingly, to be claimed against the force of certain commonsense objections. The generic

essence of these objections might be distilled into the formulaic question: "if *art* is created by sensitive and skillful artists, how can an image which is, instead, *a mechanical copy of reality*, possibly qualify as art, and so lay claim to our aesthetic interest?" Time and again, this line of objection was met by explaining how films could be more than mechanical replications. Many a theorist felt obligated to challenge the highbrow doxa that film "does nothing but reproduce reality mechanically," averring that, for instance, ordinary perception is in many ways different from how film and photography represent reality.[3] To show how cinema is more than "merely photographic reproduction," one might outline how the camera "*creates* rather than just reproduces," and how it thereby participates in a unique, expressive language analogous to those of other art forms.[4] I would like to analyze (and hopefully complicate a bit) some of the earliest arguments made about film along these lines—how, especially in the first decades after the medium's emergence, film's champions addressed its evident mechanical underpinnings, and emphasized its deeper similarities to traditional art forms.

The French critic Émile Vuillermoz addressed his own aesthetic defense of film to "superficial observers" who considered cinema to be "merely a copying machine, a passive mechanical instrument of light," a contrivance to be lumped together with "hand-crank instruments, mechanical pianos, music boxes, barrel organs, street corner instruments," all of which deny "the intervention of a creative element."[5] Even earlier, in 1911, the Italian émigré Ricciotto Canudo worried that film's emergence as a genuine plastic artform was

[3] Rudolf Arnheim, *Film as Art* (Berkeley: University of California Press, 1957), 8-9.
[4] *Béla Balázs: Early Film Theory; Visible Man and the Spirit of Film*, ed. Erica Carter and Rodney Livingstone (New York: Berghahn Books, 2010), 98. Emphasis added.
[5] Emile Vuillermoz, "Before the Screen: Aesthetic (1920)," in *French Film Theory and Criticism*, ed. Richard Abel (Princeton, NJ: Princeton University Press, 1988), 1.225-6.

hampered by the cinematograph's lack of interpretive freedom, "conditioned as it is to being the *copy* of a subject, the condition that prevents photography from becoming an art."[6] To this recurrent concern over cinema as an (apparently) reproductive technology, otherwise diverse critics proposed similar sorts of solutions: that photographic film was not entirely reproductive after all; that it was susceptible to creative interventions; that it could be given form; that it was part of a unique and coherent language; that ingenious filmmakers would discover and develop the medium's intrinsic capacities. In each case, film's original sin—its mechanical basis—was to be redeemed by demonstrations of creativity, authenticity, and genius.

This recurring rhetorical pattern—raising, then resolving, concerns about film's problematic relation to mechanical reproduction—points to a series of underlying questions. What sort of thing did film seem to *reproduce*? What was its *manner* of reproduction? Why did its mode of production *matter*? What forms of engagement, or of social organization, finally corresponded to this peculiar mechanism? While variants of these questions were generally in the air for theorists of the young medium, they manifest in ways both naïve and revealing in three American texts of the 1910s: Vachel Lindsay's *The Art of the Moving Picture* (1915); Victor Freeburg's *The Art of Photoplay Making* (1918); and Hugo Münsterberg's *The Photoplay: A Psychological Study* (1916).

In the American context, motion pictures were repeatedly measured against the achievements of the "legitimate stage," in relation to which the "photoplay" was regarded as a degraded substitute and existential threat. Film's mechanical basis was stereotyped in the

[6] Canudo, "Birth of a Sixth Art," in *French Film Theory and Criticism*, 1.61.

recurring label of "canned theater" or "canned drama"—an image that alluded to the movies' assembly-line production logic, their manufacture of numerous identical units, and the assumption that they were cheap substitutes for a live performance. The complaint with "canned drama" often involved an extended nutritive metaphor, coupled to questions of social stratification and moral hygiene. As the prominent theater critic Walter Prichard Eaton put it, "In practically shutting off the proletariat from the spoken drama, as we are doing . . . and throwing them back on an exclusive diet of motion pictures, what are we doing to them? . . . . The question is not between the movies and nothing, but between the movies, the average five- and ten-cent movies . . . and the spoken drama—in other words, between a semi-mechanical pantomime and a fine art."[7] Eaton's rhetoric reflects typical patrician concern over the withering of culture, hailing his reader as part of an "us" whose burden it is to worry about "them," the unkempt masses. But there is also complexity in his critique, to the extent that it frames the spread of motion pictures as a way to condemn existing power relations—as a sign that America's social logic would generally provide the proletariat with a cheap alternative, whereas the genuine article remained the exclusive possession of the elite.[8] The movies, in a sense, had produced the semblance, but not the substance, of democratically accessible art; and they had done so by displacing and weakening that medium (the theater) which, in Eaton's view, remained the best hope for convening and promoting public dialogue across the spectrum of wealth and power, so that "almost the entire wage-earning population [has turned] away from the spoken drama to the infinitely inferior and spiritually stultifying mechanical film-play."[9] He was, in retrospect, probably right to see in the schism of stage

[7] Walter Prichard Eaton, "Class-Consciousness and the 'Movies'," *Atlantic Monthly* 115 (1915): 53-4.
[8] Eaton, "The Canned Drama," *American Magazine* 68 (1909): 493-500.
[9] Eaton, "Class-Consciousness and the 'Movies'," 56.

and screen a portent of broader cultural trends, especially the yawning gap between the ways and means of the elites and those available to the proletariat. But defenders of film would discredit his presumption that the movies, as such, were incapable of fulfilling theater's democratizing functions—hedging that mass-produced culture might not be such a bad thing,[10] or else asserting that film's mechanism did something other than replicate theatrical performance.

America's putative film theorists, often writing in the same organs as critics like Eaton, invoked similar concerns over social hygiene, art's significance to a democratic commonwealth, and the nature and pertinence of film's mechanical associations. They urged optimism for motion pictures by showing how far they departed from theater—that, contrary to the "canned drama" epithet, the movies were a unique and individuated medium, exemplified time-tested aesthetic principles, *dynamized* (not duplicated) traditional art forms, and engendered new, politically potent forms of spectatorship. Vachel Lindsay, the popular poet and occasional film critic for *The New Republic*, is exemplary for how he integrates these complementary lines of defense. The great theme in Lindsay's book, *The Art of the Moving Picture* (1915), is an interpretation of film as a new evolution in the *plastic* arts. Where conventional accounts saw the photoplay as deriving from the performing arts—a material record (on film) of a theatrical performance, a graphic copy of an originally temporal phenomenon, much as a phonograph recorded and physically preserved a musical performance—Lindsay saw film as *producing*, rather than registering, movement. More

[10] "Another mechanical invention which transformed the face of society was the printing-press, the device by which books which had hitherto been the luxury of the rich became the easy possession of all men. And now comes the motion picture, which does for the drama the same thing which the printing-press did for literature,—it popularizes that which hitherto had been a monopoly of the well-to-do. Our age is the age of the 'canned drama,' and the cans are so small and low-priced that everybody may buy them." Herbert Atchinson Jump, "The Social Infuence of the Moving picture," *The Playground* (June, 1911), 6-7.

precisely, the movies *dynamized* the static arts of sculpture, painting, and architecture; they put traditional forms (and aesthetic logics) into literal motion.[11] He advances this thesis by focuses on a constellation of dominant (albeit idiosyncratically defined) genres, each of which elaborates some primitive cinematographic trope. He then shows how each of these inherently cinematographic genres corresponds to a different art form, translating the plastic qualities of the latter into forms of physical movement. The "Action Picture," for example, is a genre developing the primitive appeal and narrative logic of the highway chase, and producing the aesthetic effect of "Sculpture-in-Motion"; the basic unit of the "Intimate Picture" is the facial close-up, giving us "Painting-in-Motion"; and the "Splendor Picture" evolves the photogenic thrill of assembled crowds, which equates to "Architecture-in-Motion."[12]

In 1918, a few years after Lindsay's book, Victor Freeburg would conceive motion picture artistry as a real (but so far unrealized) possibility. To "elevate" movies artistically, he argues, filmmakers would need to translate the screen's striking but ephemeral pleasures into the "permanent values of illuminating truth, universal meaning, and unfading beauty"—a task which he distills into the Mary Poppins-esque formula, "[to feed] the crowd with philosophy" by "[incasing] it in the sugar coating of emotional entertainment."[13] To achieve such permanent and universal values, he continues, the filmmaker should make his images accord with the durable principles of pictorial composition, as opposed to producing surfaces

[11] Vachel Lindsay, *The Art of the Moving Picture* (New York: MacMillan, 1915), 4. "Action Pictures are sculpture-in-motion, Intimate Pictures are paintings-in-motion, Splendor Pictures are architecture-in-motion."
[12] Lindsay's explanations of these film-art correspondences are generally impressionistic rather than demonstrative. Often he asks his reader to peruse the production stills printed in popular magazines, and to confirm for themselves that they resemble classic works of sculpture, or painting, and so on. The more intriguing thesis that sculptural or painterly principles are somehow *translated* to the register of movement is, sadly, not really developed.
[13] Victor Freeburg, *The Art of Photoplay Making* (New York: MacMillan, 1918), 25.

whose organization is haphazard, or merely decorative.[14] As with Arnheim's thematic devotion to *form*, Freeburg fixes upon *composition* as the principle that will decide cinema's fate among the arts. Movies can function aesthetically so long as their imagery responds to compositional decisions on the part of the filmmaker, and while Freeburg acknowledges that such decisions are possible (primarily in the selection and arrangement of appealing subjects to photograph), the mechanical nature of photographic media tends to delimit this field of action.[15] More critically, photographic technology tends, in his judgment, to foster imitative habits—leading filmmakers to ape the *look* of classic paintings without, however, meaningfully absorbing and embodying the *principles* which underlay those masterpieces and gave them life.

Where Lindsay's film theory presents a patchwork of loose, quixotic analogies, and Freeburg grounds film aesthetics in a set of semi-intuitive principles of composition, Hugo Münsterberg's 1916 *The Photoplay* attempts a more systematic account of the medium. Like his American interlocutors, Münsterberg's argument acknowledges, and moves to contradict, the popular prejudice that the movies are degraded theatre. Rather, he argues, film's originality as an art form (and its radical distinction from the stage) consists in its striking correspondence with aspects of human psychology, a correspondence he was of course apt to see, given his status as (perhaps) the preeminent experimental psychologist of his day.[16] Münsterberg's frame of analysis gives an altogether different sort of relevance to film's mechanical components: their significance lies less in their tendency to copy reality or

[14] Freeburg, *The Art of Photoplay Making*, 23, 26.
[15] Freeburg, *The Art of Photoplay Making*, 34-5.
[16] Robert Michael Brain notes that Münsterberg conceives film in line with his experience with other experimental devices in laboratory psychology. "Self-Projection: Hugo Münsterberg on Empathy and Oscillation in Cinema Spectatorship," *Science in Context* 25, no. 3 (2012): 329-353.

imitate other art forms, but in how they structurally resemble and interact with our innate psychic apparatus—in particular, our faculties of perception, attention, memory, and association. Münsterberg's theory, his fusion of aesthetics and psychology, involves an ambiguous interplay of freedom and compulsion, voluntary and involuntary action. Much of his discussion dwells on several distinctive filmmaking techniques, which he praises for their power to "compel" the viewer's involvement in the visual text. The close-up at once resembles and commands our powers of attention; the "cut-back" (flashback) similarly mimics and channels memory; parallel editing corresponds to associative thought, lighting solicits our emotional perspective, and so on. Münsterberg tends to describe this process as an "objectivation" of our mental functions. "*The close-up*," he writes, "*has objectified in our world of perception our mental act of attention . . . . In both cases* [i.e., the techniques of the close-up and the 'cut-back'] *the act which in the ordinary theater would go on in our mind alone is here in the photography projected into the pictures themselves.*"[17]

Münsterberg's alloying of film technique and psychology anticipates aspects of psychoanalytic film theory—especially the degree to which his theory envisions a kind of composite apparatus, the film viewer's cognitive networks extending (both literally and figuratively) the mechanics of the projected image.[18] Similarly, it is possible to read Lindsay and Freeburg as forerunners for later, more critically developed theories of spectatorship and authorship. But besides scouting territory for serious thought about the film medium, these early accounts also mean to perceive and judge the logic of their times—to make sense of the machine age through one of its most ambiguous emblems. Münsterberg, especially,

[17] Hugo Münsterberg, *The Film: A Psychological Study* (New York: Dover, 1970 [1916]), 38; 41. Author's italics.
[18] Allan Langdale, "S(t)imulation of Mind: The Film Theory of Hugo Münsterberg," in *Hugo Münsterberg on Film*, ed. Allan Langdale (New York: Routledge, 2002), 9.

engrossed himself in the photoplay because it modeled (or seemed to) the psychological principles he had discriminated through years of research. Throughout his study, he remains untroubled by the ideological implications of automated spectatorship, wherein the spectator's attention falls increasingly under the command of the filmmaker. Quite the contrary: he rhapsodizes on the prospect of a filmmaker orchestrating his techniques to "play on the keyboard of our mind and secure the desired effect on our involuntary attention."[19] He praises those attributes of filmmaking that most constrain the mental activity of the spectator, those which hem in the ambit of our voluntary thought and reduce us, instead, to our reflexive obedience to textual cues.

Münsterberg posits a domineering model of aesthetic experience, but he uses it, almost perversely, to counter a mechanical view of film. In this model, film's automatism describes the structural analogy and active complicity of mind and screen, which in turn wins for film its creative vitality, its autonomy from a strictly physical, causal, reproductive order of existence. The automatisms governing film turn out to follow psychic principles rather than mechanical laws.[20] As Münsterberg puts it in his "unified principle": "*the photoplay tells us the human story by overcoming the forms of the outer world, namely, space, time, and causality, and by adjusting the events to the forms of the inner world, namely, attention, memory, imagination, and emotion.*"[21] Conscientious use of lighting, close-ups, and editing, are the means by which filmmakers claim an unequaled intimacy with the architecture of human mentation. And this affinity with mental principles makes their work creative and

[19] Münsterberg, *The Film*, 36.
[20] Münsterberg was a key exponent of the theory of "psychic automatism"—i.e., that mental phenomena unfolded in accordance with psychic laws, which could be studied empirically and thereby associated with physical causes and manifestations, but which were in no sense identical with nor directly determined by those physical factors. See Brain, "Self-Projection."
[21] Münsterberg, *The Film*, 74.

meaningful and "transformative," not "imitative." Like other theorists of the era, Münsterberg sees cinema as a culturally momentous encounter of modern technology and human vitality—of mechanical invention and artistic craft, standardized reproduction and unfettered creativity. And if this encounter seems, to many, an example of mechanism usurping the station of art—by mass producing artistic facsimiles cheaply and efficiently and unerringly—, his psychological analysis shows how deeply mistaken this first impression is. In the case of film, the encounter of art and machine shows the latter adapting itself to the forms of the former, the objective components of the motion picture apparatus conforming at last to the ways and means of the embodied mind.

Mechanism and Photography in the Nineteenth Century

Münsterberg's aesthetics, it has been pointed out, seem to assume a Kantian outlook, philosophically segregating the mechanical operations of the physical world and the realm of cognitive operations.[22] This paradigmatic division of the mechanical and the mental similarly framed responses to photography throughout the nineteenth century, especially when they evoked the ambiguous specter of "the machine." The machine was not only a figure for practical aid in mass production, but was a symbol of efficient action as such, an embodiment of mindless and exact repetition. It was a token of full-scale industrialization, instrument and emblem of a newly rapacious economy. But even more deeply, the machine was the practical representative of a philosophical system which spurred, and was increasingly emboldened by, the progress of technical invention. The philosophical doctrine of "mechanism" was the counterpart to progress in the empirical sciences, its theses

[22] Brain, "Self-Projection"; Langdale, "S(t)imulation of Mind," 16.

promulgated by the writings, experiments, and examples of Newton, Descartes, Roger Bacon, and other luminaries of the Royal Society. Simply put, the mechanist position holds that the cosmos is made up of matter—and *only* matter—acting in accordance with determinate laws.[23] In mechanism's classic formulations, God is the agent who originally enacted Nature's immutable laws; and these laws, though they might in some instances exceed human reckoning, generally disclose themselves to rigorous observation and experiment. The orthodox mechanist rejects as unscientific any account of nature that appeals to non-mechanical forces, immaterial causes, or intelligent governance within the world.

The romantic response to the rise of mechanist philosophies involved, as we will see, a compensatory emphasis on the distinct logics of "life," or "mind," or, more broadly, the organic realm. The notion that vital systems generally resisted mechanistic systematizing was especially prominent among the romantics of the early nineteenth century, for instance in the views of Samuel Taylor Coleridge. Coleridge was, in himself, a unique inflection point between the flowering of romanticism in Germany, and the later romantic movement among English poets and aestheticians. And so his discussions of mechanical philosophy articulate the mood in which both Continental and British romantics rejected this intellectual inheritance. "The mechanic system," Coleridge writes, "knows only of distance and nearness, . . . the relations of unproductive particles to each other; so that in every instance the result is the exact sum of the component qualities, as in arithmetical addition."[24] Qualities, in mechanistic systems, are reduced to quantities; complex phenomena are

[23] Robert Boyle, *A Free Enquiry into the Vulgarly Received Notion of Nature* (Cambridge, U.K.: Cambridge University Press, 1996 [1686]).
[24] Quoted in M. H. Abrams, *The Mirror and the Lamp: Romantic Theory and the Critical Tradition* (London: Oxford University Press, 1953), 174.

analyzed into series of simple ones; the world's sensuous texture rendered into a determinate field of matter in motion. "In Life," on the other hand, "the two component counter-powers actually interpenetrate each other, and generate a higher third including both the former."[25] To understand what is essential to living beings, and how this extends from life into creative works, Coleridge contends that we must appreciate processes that are inherently dynamic, which evolve dialectically rather than additively, which *grow* intelligently, rather than rearranging matter according to iron-clad laws.

The meaning of "mechanism" was, to be sure, a shifting target throughout the nineteenth century, involving critical interpretations premised on mechanical worldviews, or devices based on clockwork technics or, as Joel Snyder has stressed was the case of photography, the "skills of hand" that produce a given artifact.[26] These varied, nuanced, and evolving senses of "mechanical" make it important to specify and contextualize what the charges against photographic mechanism really meant. In the classic nineteenth-century debates over the artistic viability of photography, some opposition between mechanism and creativity was clearly felt to be at stake. Just as early film theorists would worry that a purely mechanical process could never render art, Victorian responses to photography often concluded that photography's autogenic drawings were defined by a mechanical agency. For Lady Elizabeth Eastlake, photography was not, and could never hope to be, an artistic medium—yet it was valuable in relieving artists of certain imitative burdens (as in the demand for accurate family portraits) and in helping critical eyes to discern "that mystery

[25] Quoted Abrams, *The Mirror and the Lamp*, 174.
[26] Joel Snyder, "Res Ipsa Loquitur," in *Things that Talk: Object Lessons from Art and Science*, ed. Lorraine Daston (New York: Zone Books, 2004), 202.

called Art" by, as it were, "simply… showing what it is not."[27] Photography bested any human peer in accurate delineation and completeness of detail, but these were only the technical, mechanical prerequisites to artistic depiction anyway. It could play no role in the artist's "power of selection and rejection, the living application of that language which lies dead in his paint-box, the marriage of his own mind with the object before him, and the offspring, half stamped with his own features, half with those of Nature, which is born of the union—whatever appertains to the free-will of the intelligent being, as opposed to the obedience of the machine…"[28] The phenomenon of photography, in Eastlake's view, embodied all those aspects of artistic execution that could be carved away without touching art's own beating heart. Photography was mechanically driven, enslaved to natural law, technically perfect, whereas art described the conspicuous intervention of human personality, intelligence, sensitivity, and freedom.

Photography did not engender this theoretical opposition between technical perfection and human genius all at once, or all on its own; nor did it introduce mechanical copying as the logical antithesis of intelligent creation. But the photograph gave these aesthetic principles a vivid and marvelous example—a kind of symbolic apotheosis of the competing claims of technique and artistry—as well as a new sense of urgency.[29] For some critics, it was the popular spread of photographic techniques that revealed their affinity with the destructive ethic of industrial modernity, belying whatever cultural promise the medium

[27] Lady Elizabeth Eastlake, "Photography," in *Classic Essays on Photography*, ed. Alan Trachtenberg (New Haven, CT: Leete's Island Books, 1980), 66.
[28] Eastlake, "Photography," 66.
[29] Aaron Scharf makes a similar point in observing that most of the *effects* associated with photography could be found in earlier paintings. "What is important, however, is that none of these things, nor other of the kind, had any currency in nineteenth-century European art until they appeared in photographs, and if photographs did not in themselves suggest entirely new conventions, by their authority, at least, they must often have confirmed ideas already germinating in the minds of artists." *Art and Photography* (Baltimore: Penguin, 1974), 11-12.

might have had. Upon first witnessing Daguerre's "most blessed invention," John Ruskin had declared: "among all the mechanical poison that this terrible 19th century has poured upon men it has at any rate one antidote—the daguerreotype."[30] By Ruskin's initial reasoning, photography might preserve and defend England's natural spaces, which were increasingly vulnerable to industrialism's rampant progress, and could improve the stock of working artists by culling any uncritical, mechanical copyists from their ranks. Photographic technics could help Victorian society discern, and resist, the mechanical impulses at work in individual works and in the economy writ large. But this initial hope soon soured, and in his later years Ruskin saw photography, not as an "antidote" to world-consuming technics, but as their accomplice. Instead of crystalizing the inimitable core of artistic genius, photography had reinforced in its public the materialist dogma that "you may substitute mechanism for skill, photograph for picture, cast iron for sculpture."[31]

Ruskin was joined by other European critics who bemoaned both the mechanical agency at work in photography, and the spread of materialist attitudes (and among these, especially, a defiant skepticism about artistic distinctions) that this agency heralded. The art critic Philip Gilbert Hamerton characterized his own "rather long and dogmatic" polemic against photography as being formed "in answer to a declaration made by one of my friends to the effect that 'the discovery of photography had made painting no longer of any use, since all that painting did could be done much more truthfully by the photograph.'"[32] Across the

[30] Quoted in Michael Harvey, "Ruskin and Photography," *Oxford Art Journal* 7, no. 2 (1984), 25.
[31] John Ruskin, "The Relation of Art to Use," in *Lectures on Art* (Oxford: Clarendon, 1875), 95. The full passage reads: "almost the whole system and hope of modern life are founded on the notion that you may substitute mechanism for skill, photograph for pictures, cast-iron for sculpture. That is your main nineteenth-century faith, or infidelity. You must think you can get everything by grinding—music, literature, and painting. You will find it grievously not so; you can get nothing but dust by mere grinding. Even to have the barley-meal out of it, you must have the barley first; and that comes by growth, not grinding."
[32] Philip Gilbert Hamerton, "Photography and Painting," *Thoughts about Art* (London: Macmillan, 1873), 64.

English Channel, Baudelaire's barbed remarks on photography similarly opposed a perceived tide of public sentiment, peculiarly modern in its outlook, which saw the domain of art as territory thoroughly conquered by science. Photography, he complained, flatters the crass aesthetic of the masses who believe that "art is, and can only be, the exact reproduction of nature" so that this new "industrial process," in rendering nature's surfaces so precisely, must be counted as the "absolute art."[33] Genuine aesthetic virtues—"the sphere of the intangible and the imaginary, . . . anything that has value solely because man adds something to it"—are meanwhile abandoned.[34]

The aesthetic criticism of photography, as represented by Eastlake, Ruskin, Hamerton, and Baudelaire, in many ways set the stage, and the terms of debate, for the main stream of critical responses to cinema a few decades later. In both cases, photography—as a mechanical tool that replaces skill, labor, and attention in delineating visible surfaces—offsets and so clarifies the human element in artistic making. The dignity of art, by this reasoning, must consist in its difference from a purely mechanical product, must derive from the human distinctions of imagination, sensitivity, interpretation, care, and fantasy. And so a number of critics, artists, and photographers opposed the likes of Ruskin and Baudelaire by specifying how and where human faculties collaborate in the work of photography. Among these was the American artist Henry Rankin Poore, whose book on pictorial composition powerfully influenced Freeburg's views on film art. Poore acknowledges that most photographs will fail as art, but that these failures are due less to the mechanism itself than to a haphazardness in handling it. Accordingly, photography helps reveal the principle of

[33] Charles Baudelaire, "The Modern Public and Photography (1859)," in *Classic Essays on Photography*, 86.
[34] Baudelaire, "The Modern Public and Photography," 88.

composition—which concept was the cornerstone of Poore's aesthetic philosophy.[35] Photography's potential as art, since it obviates so much of manual technique, lies entirely in compositional principles—the careful arrangement of bodies within the frame, attention to balance and line, light and shade—which, in the end, must have always been true for painting and the other plastic arts as well. These earlier images surely required greater (or at least different) resources of manual labor and dexterous skill; but their artistry did not consist in these skills, but was bound up entirely with the question of intelligent composition. Picking up the Ruskinian charge that photography was inherently bereft of design, feeling, or imagination, Poore countered that "Invention and design, feeling and imagination are all part of the photographer's suite. . . . Technique, which is manual and not spiritual, is the one point at which art and photography cannot coalesce."[36] Accordingly, he proposes the following aesthetic guideline for photography: "In whatsoever degree more of the *man* and less of the *mechanics* appear, *in that degree* is the result a work of art."[37]

In wedging photographic practice between art and non-art, Poore's account prefigures the rationale of theorists assessing film a few years later. And like subsequent critiques of film in its enmeshment with mass industry, the question of photographic aesthetics seems to serve as a proxy for a deeper ideological schism—namely, a primal opposition between mechanical and intelligent processes, between the ways of machines and those of human beings, between the inorganic products of determinate agencies and those that exhibited deliberate, intensive organization. Photography's disputants generally shared the assumption

[35] "The best things, discoverable to the writer, in the field of composition, have been by photographers themselves—the best things as well as the most inane." H. R. Poore, *Pictorial Composition* (New York: Baker & Taylor, 1903), 184.
[36] Poore, *Pictorial Composition*, 182.
[37] Poore, *Pictorial Composition*, 184. Original italics.

that an artwork's value (its value *as art*) derived from non-mechanical agencies, and that a photograph's aesthetic merit could be decided only by discriminating the contributions of the photographer from those of her apparatus. Poore's principles of composition, as a result, prove to be principles qualifying the agent rather than the image. Rembrandt's effects derive their interest and legitimacy from the deliberate strokes of the artist; similar effects in a photograph, if produced accidentally by a smudged lens or imperfect lighting, are sterile. Composition teaches us to appreciate the composing force more than the resultant form.

A polarity of agencies governed the aesthetic estimation of photography: on the one side, mechanism; on the other side, whatever was left over, in external nature or in human intelligence, once accounting for the world's mechanical forces. Human beings might behave more or less mechanically in their artistic process—whether by employing a photographic camera, or some other optical aid, or by methodically and unthinkingly tracing their model. But the aesthetic value of the work depended solely on the artist's non-mechanical contribution: her imagination, inspiration, feeling, genius, or form-giving eye. While a canon of art criticism viewed photography as embodying a strictly *mechanical* agency, that agency also prompted more ambiguous conceptualizations, especially in the new medium's early years. In the next two sections, I will explore how the automatism at the heart of early photographic processes—those chemical agencies that were so poignantly independent of human guidance and control—evoked not just the rival parentage of science and art, but a marked affinity for plants and for the organic philosophies in which plants and the imagination were spiritually linked.

Art, Organisms, and Botanical Creativity

Coleridge's antipathy to mechanical philosophy, discussed in the previous section, found echoes in other English romantics like Wordsworth and Carlyle and in the diverse critics marked by their influence—including, of course, much of the critical response to photographic technologies. But Coleridge was also a conduit for a tradition of philosophic and scientific thought that had been thriving in Germany around the turn of the nineteenth century. Coleridge was particularly affected by the *Naturphilosophie* of Schelling (whom he at one point planned to translate), by Schelling's disciple Henrik Steffens, by the proto-evolutionist physiology of Johann Friedrich Blumenbach, and by the historical philosophy of Herder.[38] At the center of this German intellectual movement was Kant's critical philosophy, with its profound reconstruction of the ancient notion of teleology—an exercise which Arthur Schopenhauer later called a "baroque union" of aesthetics and biology.[39] In its least technical sense, "teleology" had meant the comparison of certain natural formations to manmade artworks and artifacts—the feeling that nature itself appeared to have been designed. Aristotle, in his classical treatment of teleology, outlined how certain organic structures seemed to follow an idea, plan, or end conceivable prior to and independent from the structure's material existence. But he declined to join this appearance of intelligence or orderliness to any deeper ontological insight. Christian theologians, writing in Aristotle's wake, used teleology to make a deistic deduction: that designedness in nature was simply evidence of God's creative imprimatur. Kant, however, sought to rethink teleology outside

[38] On the range of Coleridge's influences and borrowings from German romantic philosophy, see Trevor H. Levere, "Coleridge and the Sciences," in *Romanticism and the Sciences*, eds. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge University Press, 1990), 295-306; and *Poetry Realized in Nature: Samuel Taylor Coleridge and Early Nineteenth-Century Science* (Cambridge: Cambridge University Press, 1981).

[39] Quoted in Hannah Ginsborg, "Kant on Aesthetic and Biological Purposiveness," in *Reclaiming the History of Ethics: Essays for John Rawls*, eds. Andrew Reath, Barbara Herman, and Christine M. Korsgaard (Cambridge: Cambridge University Press, 1987), 330.

the frame of faith, through the epistemological and ontological implications of his critical philosophy.

To appreciate how plants informed romantic thought about creative process, and how these philosophical tropes in turn framed early conceptualizations of photography, it is worth making a brief detour into Kant's account of teleology. Even now, and even in light of his incomparable influence on the generation that followed him, Kant's approach and conclusions regarding teleology remain a subject of scholarly dispute.[40] For Kant, the crucial concept linking our aesthetic judgments and our investigation of organic nature is what he terms *purposiveness*. He defines purposiveness broadly as "the causality of a concept with regard to its object"—that is, the sense that some phenomenon not only corresponds to an intellectual category, but actually seems to have been formed according to a mental concept or plan, and not by chance or by natural law.[41] Archaeological artifacts are the simplest examples of objective purposiveness: we understand these objects as manmade, and we make sense of their form by inferring the practical purpose or end their maker had in mind for them. The roundness, smoothness, symmetry, and hollowness of an unearthed pot, for example, are not qualities we attribute to random chance; rather, they cohere in a form highly suited to a human use—conveying liquids—and which we know from experience are often made by human craftsmen.[42] On the other hand, borrowing Hannah Ginsborg's example,

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[40] See, for example, Timothy Lenoir, "Teleology without Regrets: The Transformation of Physiology in Germany: 1790-1847," *Studies in History and Philosophy of Science Part A* 12, no. 4 (1981): 293-354; Robert J. Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2010); Hannah Ginsborg, "Kant on Aesthetics."

[41] Immanuel Kant, *Critique of the Power of Judgment* ed. Paul Guyer, trans. Paul Guyer and Eric Matthews (Cambridge: Cambridge University Press, 2000), 105.

[42] Kant also refers to stone tools unearthed during archaeological digs, for which we may not in fact be able to discover their original purpose. In this case, the object is clearly purposive, and (unlike organic structures) was surely created according to some determinate (human), if unknown, purpose. *Critique of the Power of Judgment*, 120.

consider the humble crab—the subtle architecture of its hard shell, the practical, radial symmetry of its eight legs.[43] The crab's shell is suited to the purpose of protecting vulnerable flesh from predators; its legs allow it to navigate sandy environments; its pinchers enable it to spear or grasp prey. Its organized form, in short, elegantly satisfies its various vital requirements. Unlike the ancient pot, however, this order and coherence of the crab's shell and legs cannot be attributed to an intelligent producer of crabs. There is no empirical warrant for such a conclusion. At this point, acknowledging that we ought not to deduce an intelligent creator per se, Kant contends that we cannot avoid conceiving the crab's shell as *purposive* all the same. His solution to this paradox is to distinguish *purposiveness*, as a quality exhibited in biological forms, from the ascription of empirical *purposes* or *ends*: "purposiveness can thus exist without an end, insofar as we do not place the causes of this form in a will, but can still make the explanation of its possibility conceivable to ourselves only by deriving it from a will."[44] In short, we can—and, for the purposes of rich understanding, we *should*—note an organ's purposiveness, without projecting a correspondingly purposeful agent at its origin.

In departing from the "argument from design," Kant makes the notion of "purposiveness" do subtle work. Purposiveness becomes, in his account, a dimension we cannot overlook in vital bodies; our sense for organization is in some sense primitive; and in any event, our understanding of organisms can only progress if we acknowledge their rational, purposive forms. Later critics have interpreted Kant as offering a merely "regulative" concept of teleology: that naturalists must treat the organic realm "as if" it had

[43] Ginsborg, "Kant on Aesthetics."
[44] Kant, *Critique of the Power of Judgment*, 105.

been designed intentionally if they want to make other, empirically valid conclusions about it.[45] Others have countered that Kant's thesis is deeper and more mysterious than this—that it prefigures the view propounded by later romantics that intelligence is imminent to organic bodies, vital processes, and even to the unfolding life of the cosmos. Even today's least theistic Darwinians cannot avoid linguistic nods to purposiveness, conjuring images of "selfish genes," equating an adaptation's "purpose" with its conferral of some pre-historic survival advantage, referring the "function" of livers and kidneys to the holistic orchestration of vital "systems," or specifying the niche or "role" played by honeybees in a teeming, internally calibrated ecology.

In Kant's philosophy, human judgment finds purposiveness both in works of art (and other made objects) and in organisms (and other organic bodies). More grandly, Kant's sense of nature's purposiveness "provides the mediating concept between the concept of nature and the concept of freedom, which makes possible the transition from the purely theoretical to the purely practical, from lawfulness in accordance with the former to the final end in accordance with the latter."[46] Another way to put this is that organic purposiveness shows the relationship between reason—which seeks, independently of experience, the universal ethical imperatives to which we refer our free actions—and the understanding, which construes the mechanical laws governing physical bodies.[47] Kant's treatment of

[45] One must, for example, study the human heart "as if" it were "meant" to pump blood, even though we cannot impute its rational design to any knowable designer. For an extended discussion of how Kant's regulative teleology influenced subsequent biological research, see Timothy Lenoir, "Teleology without Regrets: The Transformation of Physiology in Germany: 1790-1847," *Studies in History and Philosophy of Science Part A*, 12, no. 4 (1981): 293-354. Robert Richards, among other historians of science, has questioned how strictly "regulative" Kant's teleology was really supposed to be, and how literally other romantic biologists may have taken it.

[46] Kant, *Critique of the Power of Judgment*, 81-2.

[47] Ginsborg argues that Kant's analogy between aesthetics and biological purposiveness is deeper than most critics realize. In both domains, we commit ourselves to normative judgments—specifically, ones in which we judge that something "is as it ought to be," without, however, comparing that thing to a determinate concept. In

biological purposiveness clears an ambiguous space in the realm of nature for forces and qualities that cannot be subsumed within the system of physical mechanics. It also suggests that those forces and qualities most relevant to human acts of making and appreciating art—that aesthetic judgments, which seek universal agreement while soliciting the free play of the faculties, undetermined by any concept—are linked to formative powers in nature in that they could embody purposiveness without disclosing a determinate purpose.

Kant's *Critique of the Power of Judgment* put Nature's apparent purposiveness on solid philosophical ground, and disclosed essential links between forms of natural beauty and works of art. For a circle of poets, critics, and artists working in Kant's wake, the comparison of art and nature helped reform ideas about the source and logic of artistic creativity. As M.H. Abrams puts it in his classic study of Romanticism, a dramatic "analogical substitution" took place in the dominant aesthetic treatises, namely "the replacement . . . of a mechanical process by a living plant as the implicit paradigm governing the description of the process and the product of literary invention."[48] Writing under the spell of Newtonian mechanics, eighteenth-century aestheticians, especially in Britain, had invoked a set of psychic mechanisms—memory, association, and combination—to account for the creative process as such. Implicit in these accounts was the expectation that methodical inquiry would, in time, fully reveal the laws governing these mechanisms, just as it had fixed the laws of gravitation—an expectation based in the assumption that all of nature,

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the case of an organism, we judge that it is a more or less perfect example of the norm (say, the symmetry and terrestrial capabilities of a crab) or design that it seems to exemplify. This normative form of teleological judgments tells us something about the nature of aesthetic pleasure—that this pleasure (characterized by Kant as the free and harmonious play of our native faculties) is produced by the discovery that "my own act of judging is as it ought to be with respect to the object," which amounts to an "awareness of purposiveness both in the activity of [my] faculties and in the object." Ginsborg, "Kant on Aesthetics," 348.

[48] Abrams, *The Mirror and the Lamp*, 158. Hereafter cited in-text as ML.

including human organisms and their behaviors and their works, unfolded in accordance with the same mechanical laws. Such mechanical models of aesthetics were, to many, unsavory, if not paradoxical. After all, if the laws of invention could be rendered in mathematical formulae, then any literate amateur could produce an artistic masterpiece simply by following the formula, just as surely as a mechanically proficient layman could construct a working steam engine. An alternative aesthetic model held that invention could, in principle, never be given determinately; that one might copy the *effects* of great works, but not the obscure and irreducible principles that underlay them; and that, if clocks and steam engines could symbolize the workings of technical craft, truer models of artistic ingenuity were to be found among the vital, self-sustaining beings of organic nature.

Abrams yokes together a network of aestheticians whose otherwise distinct theories appeal to plants in understanding the workings of human creativity. Alexander Gerard, for example, contends that the inner logic of "genius" is not additive, like a mechanism, but assimilative and organizing, like "a vegetable [which] draws in moisture from the earth . . . and at the same time, converts it to the nourishment of the plant" (ML 167). Creativity, on this model, absorbs surrounding elements, digesting and synthesizing them into a new and vital product in a continuous, organic gesture; this product, in many cases, was itself comparable to plants and flowers. As Young puts it, "an *Original* may be said to be of a *vegetable* nature; it rises spontaneously from the vital root of genius; it *grows*, it is not *made*" (ML 199). If genius's means and ends could be seen as "plant-like," the *experience* of creation could also be illuminated through botanical analogies. Shelley, for example, emphasizes the artist's glimmering awareness and imperfect mastery of his or her creative process, an experience in which "the mind . . . is like the colour of a flower which fades and

changes as it is developed, and the conscious portions of our natures are unprophetic either of its approach or its departure" (ML 192). Addison and Pope similarly qualify this perception that genius is never its own master, suggesting that, like plants and flowers, the inventing mind is "not so much an Imitator, as an Instrument of Nature; and 'tis not so just to say he speaks from her, as that she speaks through him" (ML 188). German critics, especially, fixed upon creativity's obscure and *unconscious* undercurrents, invoking sprouting plants and budding fungi to qualify how these forces lurk just below the threshold of perceptibility and periodically catch us unawares. "Every noble human species sleeps, like any good seed, in silent germination: is there, and remains unaware of itself," says Herder (ML 205). Psychic production, Johann Georg Sulzer suggests, has an almost hypnotic force: "the thoughts and ideas which ensue from the persistent contemplation of an object . . . gather together in the soul and there germinate unnoticed, like seeds in a fruitful soil, and finally at the proper moment come suddenly to light." (ML 203).

Botanical Photograms: Figuring Contact

Just as plants furnished these kinds of deep and complex metaphors for the nature of poetic creation, they also, a few decades later, were at the center of the habits, concepts, and disciplinary alliances that guided the early progress of photography in England. Paradigms of nature's subtle intelligence, of its non-mechanical ways and means, plants were both powerful analogs in conceiving photographic process, and recurrent subjects depicted with the new medium. These depictions were often carried out through technical means that toyed with photography's standard components—specifically, forming the image by directly impressing a botanical specimen to the photographic surface, without the intermediary of the camera's projected light. These still captivating, cameraless images give us a different sense

of the source, nature, and significance of photography's automatisms, and how these automatisms bear on the creative energies, cultivating ethics, and attentive powers we develop in our interactions with plants.

The extracts in the previous section give a taste of how plants figured in the aesthetic theories, and in the wider ideological field, of the early nineteenth century. Images of plants—their unthinking agency, their subterranean life, their (literal) rootedness in their surroundings, their creative repurposing of extraneous material, their self-preserving yet indeterminate behavior—helped to discriminate mechanical processes from organic ones, and to stimulate new ideas about human inventiveness in art and in science. Given the power, malleability, and ubiquity of these vegetable metaphors, it is interesting to reflect on the ways that plants, themselves, analogize or embody the properties of depictive, storage, or communications media.[49] The widely recognized and highly resonant image of a growing plant supplied metaphorical material to be worked over in developing new concepts of, and insights into, other species of productive agency. Plants effectively helped *mediate* inquiry into the forms and sources of human creativity. To speak of the "media character" of plants is to acknowledge their conceptual usefulness, to recognize how they are "good for thinking with."[50] Complicating their media character is the fact that these botanic metaphors are themselves sourced in the representational media of literary description, painting, illustration, and printing. In identifying plants as media, we can bring out how botany and photography encountered one another in the early nineteenth century, and how this encounter suggests a sort of instinctive affinity between photograph and plant. While this encounter took several

[49] John Durham Peters speaks of plants as "great mediators," "storage media," and "fundamental infrastructures of [human] existence" in *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago: University of Chicago Press, 2015), 148, 149, 158.
[50] Peters, *Marvelous Clouds*, 148.

related forms, it is especially salient in the various experiments with botanical photograms—cameraless photographic impressions of plant specimens—produced in Britain by William Henry Fox Talbot, John Hershel, and Anna Atkins.

Reflecting on the efforts and insights that led to his discovery of an effective photographic process, Talbot described his envisioned goal as combining two distinct steps: to "fix" the fluttering image from a camera obscura, then "transfer" it to a durable surface.[51] Despite the centrality of the camera obscura to this preconception of what photography ought to accomplish, however, many of Talbot's early "photogenic drawings" did not involve the camera at all. In these alternative cases, he used a technique he termed "superimposition," which involved taking some opaque object—a leaf, a section of lace embroidery, a scattering of seeds—and laying it directly on a chemically photosensitized surface (usually paper). The object-affixed sheet would be laid in direct sunlight for a sufficient length of time, then the object removed, leaving a burnt-in outline which, with the application of a suitable reagent, could be preserved against the effects of further exposure. The resulting image would be a sort of reverse silhouette, those areas that had been exposed to sunlight having darkened, while the region covered by the object maintained some degree of the paper's original (whitish) tone. Talbot saw that this "negative" print could perform as the object for a second print, reversing the black and white fields to create what John Herschel proposed to call a "positive."[52] This appliqué technique succeeded in "fixing" and "transferring" an unstable

[51] See Snyder, "Enabling Confusion," *History of Photography* 26, no. 2 (2002): 154-160, for a critique of the conceptual tenability of this desire.
[52] Vered Maimon, *Singular Images, Failed Copies: William Henry Fox Talbot and the Early Photograph* (Minneapolis: University of Minnesota Press, 2016).

image, but instead of the focal plane of the camera projection it substituted a simpler form of impermanence—a shadow.

One reason for employing this cameraless technique was probably that it was simpler and easier than fixing a camera obscura projection.[53] These "superimpositions" (or what we now call photograms) could serve as a preliminary to camera photography: they isolated the distinct technical tasks of chemically fixing light, and then preserving that luminous impression. They deferred the additional difficulties associated with the camera's delicately patterned light projections, while also establishing a frame of reference for understanding the photographic inscription of that plane of light. Both the superimposed object and the camera projection were, to the photographic substrate, "things" defined and encoded according to their differential light values.[54] The unstable light of the camera was, in this sense, analogous to the sorts of objects most often employed in superimpositions—the delicate bodies of flowers and mosses and algae, intricately-patterned sections of lace, and the reversible images of other photographic prints. And perhaps recalling this early interchangeability of luminous projections and tangible bodies, we still speak of photographs as strangely *material* records—as "impressions," or "imprints," or "inscriptions." These metaphoric nods to the photograph's indexicality describe, more literally, the direct physical contact involved in photograms—those fossil traces effected by Talbot's "pencil of nature."[55]

Despite their seemingly intermediate, preparatory status in relation to optical photographs, cameraless photograms persisted as a subgenre tested by early photographers,

[53] Maimon, *Singular Images, Failed Copies*.
[54] See Snyder, "Enabling Confusions." Talbot describes his progress to photography in precisely these terms.
[55] Carol Armstrong, "Cameraless," *Ocean Flowers: Impressions from Nature*, ed. Carol Armstrong and Catherine de Zegher (2005), 87-180.

especially in depicting botanical subjects. In Talbot's Britain, photography and botany were sciences pursued in large part by amateur communities—communities with remarkable overlaps, it turns out. One the one side, lovers of plants indulged the opportunity to record their subjects using new photographic methods. On the other, photographic experimenters enlisted botanical specimens as test subjects as they finetuned their procedures. But the connections between photography and botany seem to run deeper than these incidental historical intersections. In the period of photography's emergence, botany as a field was increasingly concerned with questions of representation, especially the role of illustration in training the senses and educating the sensibilities of lay enthusiasts.[56] Professional botanists hotly debated whether botanical illustrations could cultivate the discipline's essential skills and virtues—acute, accurate, sustained observation in the field; an eye for fine morphological distinctions; a robust familiarity with the classification of organs, species, and genera—, or whether these drawings, however marvelous and attractive, however effective as advertising, provided ephemeral pleasures and encouraged superficial, unscientific viewing habits.[57] These debates present botany as a field distinguished by dynamic, dialogical, intensive, and profound investigations, as against the merely taxonomic routines of natural history. As one gentleman botanist put it, the science "affords excellent exercise to the powers of discrimination, & practices the memory very much," such that the "attentive examination of plants" becomes a mentally demanding enterprise, an intimate congress with "the variety of

[56] Anne Secord, "Botany on a Plate: Pleasure and the Power of Pictures in Promoting Early Nineteenth-Century Scientific Knowledge," *Isis* 93, no. 1 (2002): 28-57.
[57] Secord, "Botany on a Plate."

wonderful contrivances which Nature employs for the protection of the flower, & due ripening of the seeds, &c. [which] excite one's admiration at every step."[58]

Early botanical photograms, then, can be compared to the contemporaneous values, principles, and visual culture of botany, and to the media that embodied and sustained that culture. Given that the amateur botanist quoted above was none other than William Henry Fox Talbot, how did his photographic techniques, whereby tangible bodies transferred their forms to paper by the chemical agency of light, relate to the science's concerns with representation, aesthetic pleasure, and disciplined observation?

As practical illustrations, botanical photograms met with ambivalent success. Talbot was initially confident that the scientific community would embrace photogenic drawing as an obvious boon to botanical illustration.[59] In reply and in practice, however, professional botanists questioned the usefulness of the method of contact printing, perhaps uncertain how to place and evaluate this new technique in relation to existing modes of illustration.[60] Given the priorities of scientific illustration, this hesitancy about photography is not surprising. Illustrations, ideally, would please the eye while teaching it to identify the relevant features of a given plant, training their audience to perform as reliable observers in the field. Drawings could serve this end by magnifying a small but crucial organ, thereby revealing its form in detail, giving a sense of its function, and imparting visual information by which to draw distinctions among bodies and between species. Drawings could show accurate textures and volumes, clarify root structures difficult to discriminate in the flesh,

[58] Talbot to Elisabeth Theresa Fielding, 6 Sept 1814, Talbot Correspondence, Document no. 610. Quoted in Mirjam Brusius, "Beyond Photography: An Introduction to William Henry Fox Talbot's Notebooks in the Talbot Collection at the British Library," *BLJ* (2010, Article 14), 10.
[59] Brusius, "Beyond Photography."
[60] Brusius, "Beyond Photography," 10.

simultaneously furthering comprehension while allowing the reader to explore and take pleasure in the imagery's likeness to life. Colored illustrations (whether by oil paints or water colors) added to the pleasures of intricate delineation an appreciation for nature's delicate variety of tints and hues, and likewise acknowledged the role of color in differentiating otherwise similar forms. Where concrete examples were wanted, a lecturer might circulate actual fresh or dried specimens, the latter of which could also be mounted and assembled into an album of "natural illustrations."[61]

Given the aesthetic and epistemic functions botanical illustrations were supposed to perform, it is not surprising that, compared to the media of drawing and specimen-mounting, botanical photograms met with ambivalence from the discipline at large. Where a drawing could magnify and accentuate definitive formal minutiae, photograms reproduced original scale. Where modeling in perspective could precisely render line and texture while simulating volume, thickness, and depth, the photogram was generally insensitive to surface texture and tended to collapse a plant's variable fleshiness to the uniform flatness of a shadow. Where rich and evocative color tones could be included in an illustration, the photogram was limited to a single chromatic register.[62] For these reasons and others, cameraless photographs largely fell short of the "truth to nature" that remained the operative paradigm for scientific illustrations at this time.[63] Neither could they authenticate a specimen in the way that the specimen itself could, once it was dried and mounted in an album, the photogram's ghostly imprint paling in comparison to the plant's bodily presence on the page.

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[61] Secord, "Botany on a Plate," emphasizes the ways in which drawn illustrations and physical specimens were used in conjunction during lectures; Armstrong, "Cameraless," 147, discusses the popularity of "nature print" albums.
[62] For more on this comparison, see Armstrong, "Cameraless."
[63] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).

Finally, one must remember that botanical illustrations were labor-intensive endeavors, requiring hours of patient inspection and intensely detailed pencilwork, all the while honoring all, and only, the plant's essential attributes. This labor was often seen as conducive to the science's core principles, training the eye of the illustrator and inspiring corresponding habits in the viewer.[64] Talbot's *photogenic* drawings, however, were distinguished from other botanical drawings by their automatic process, by the fact that the manual skill and labor of faithful depiction were taken over by a nonhuman agency. How could the resulting images hope to impart properly scientific skills and habits and sensibilities when they contained none of this ocular and manual labor?

Despite the early photograph's deficiencies as a medium for illustration, botanical enthusiasts continued to experiment with photograms of vegetable subjects, often with strangely compelling results. Given this magnetism between medium and subject, it is tempting to invoke notions of an inherent affinity between them, based in their shared constitution by light and chemistry. William Hirsch gestures in this direction, citing the camera obscura effects that are sometimes produced by sunlight filtering through clustered foliage; Beaumont Newhall similarly associates the photochemistry of the prepared plate to the photosynthesis performed by a plant's leaf, each surface receiving light's energy and converting it into vital material—a picture, in the first case; sustenance, in the second.[65] The plant's responsiveness to light defines its being, from its phototropism as it sprouts and matures, to its light-fueled internal chemical conversions, to the seasonal tanning and turning of its foliage in response to changing light values. The photograph, seen at first as a de-

[64] Secord, "Botany on a Plate."
[65] Robert Hirsch, *Seizing the Light: A Social and Aesthetic History of Photography* (New York: Routledge, 2017), 23. John Herschel also made the case that "photographic processes 'pervade all of nature.'" See Maimon, *Singular Images, Failed Copies*, xxv.

skilled, instantaneous, and mechanically perfected form of drawing, was more specifically imagined as a drawing effected by light, or by nature.[66] Talbot called his first book *The Pencil of Nature*, and later referred to the images produced by his process as "heliographs," sun-pictures. Perhaps there was always something plant-like about the autogenesis of the photograph, and perhaps this internal correspondence impelled these early applications of photography to plant specimens.

Early botanical photographs seem to have operated at a remove from the scientific protocols of the era: they largely failed to reproduce important visual data, and seemed poorly suited to inculcating habits of strenuous and acute observation. Yet these images can claim significance as tokens of an unspoken affinity between plant and photograph, and between the communities of amateurs devoted to these passions. They explore this correspondence of subject and medium, staking their effect not on classificatory criteria and surface comparisons, but on submerged ontological entanglements. Carol Armstrong makes a similar point when she argues that Anna Atkins used marine flora as vehicles for testing the unique capacities and limitations of photography.[67] Following this line of reasoning, the known properties of plants serve as stable reference points for measuring the tendencies, strengths, and weaknesses of different photographic processes. But in framing the relationship in this way—emphasizing the extent to which botanical analogies seep into the conceptual matrix of photography—we might miss out on how the phenomenology of the photogram might have inflected and reformed understandings of plant life. In working out certain vague intimacies between the organic and the photographic, these experimental

[66] On the importance of photography's "de-skilling" in particular, see Stephen Edwards, *The Making of English Photography: Allegories* (University Park, PA: Penn State University Press, 2017).
[67] Carol Armstrong, "Cameraless."

images point, more specifically, to the symmetry of their *agencies*. Photographs form their images in ways that recall the light-driven development of plants; in portraying plants, they emerge as emblems, also, of the organic world's inherent and variegated power to create. Besides reminding us of the plant's power to assimilate external matter and organize its own vital tissues and forms, these botanical imprints suggest that the plant's organic agency extends into the making of images.

This bridging of vital and aesthetic agencies is accomplished, significantly, through the modality of contact. In her reading of early botanical photograms, Vered Maimon stresses how "in their mode of formation and compositional and formal aspects, nature appears as a dynamic force of life."[68] In other words, the aesthetic features of these images paint nature, not as a determinate field of mechanical causes and effects (a "blind whirl of atoms," as Mumford puts it), but as an agency capable of introducing novel, indeterminate forms into the world; an agency possessed of its own peculiar intelligence.[69] Building on this reading, I want to dwell specifically on the notion of contact it contains—how physical contact distinguishes the method of "superposition"; how we come to recognize contact in the image itself (how, that is, the image comes to signify its mode of formation); how this evocation of contact intensifies our fascination with the images themselves; and how, finally, how these photographs mobilize and develop our appreciation of "contact" as a formative agency.

In drawings of botanical subjects, the artist often sought (as in other realist arts) to eliminate as far as possible any sign of the author's touch. This reduction of one kind of

[68] Maimon, *Singular Images, Failed Copies*, xxv.
[69] Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace & World, 1963 [1934]), 217.

signature allowed for another to emerge from the picture: to whatever degree the artist and her art were diminished in the picture, to that same degree was the observer's sense of *nearness* (to nature) increased. The ideal which botanical drawings asymptotically approached was one in which, the artist finally erased, the beholder's sensibilia were fully in contact with the plant. In platonic fashion, one was nearer to the idea of the plant than one would be in gazing upon any individual specimen. Photographs, as a contemporary reviewer observed, erased the handiwork of the artist all but completely: they were "charactered by nothing like human handling; there was no resemblance to touch, for the eye to rest upon."[70] The method of superposition brought this ideal of nearness to nature, of directness, and of nature's physical participation in the image, to an apotheosis. Here, the organic agency of the plant worked even without the figural mediation of camera optics, marking the photographic surface directly, productively, and automatically.[71]

As Armstrong discusses, botanical photograms were not unique for involving the botanical body's physical participation in rendering itself. The same could be said for the dried and mounted specimens known as "natural illustrations," which could be assembled into albums; it was likewise true of the various processes of "nature printing" employed by botanical illustrators.[72] In a nature print, a specimen (a leaf, say, or a flower) was lightly coated with soot or ink, then pressed onto paper so that it faithfully stamped its outline,

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[70] "The Talbotype—Sun Pictures," *Art-Union*, June 1846, 143. Quoted in Maimon, *Singular Images, Failed Copies*, 118.

[71] Theorists of photography have tended to collapse into a single issue the removal of the artist's hand and the direct participation of nature: these facts are part of the standard equation that establishes the photograph as an indexical image. It is possible, however, to disentangle them into questions with distinct valences and significance. Photography was "mechanical," in the 1830s sense of the term, in the specific sense that it saved human labor (Edwards, *Making of English Photography*; Snyder, "Res Loqua Opitur"). But what it replaced that labor *with* was significant in a different sense. To the extent that the automatic agency in question was not one of a clock, but of a vegetable, the imaginative power and associations of photographs took on a different character.

[72] Armstrong, "Cameraless," 149.

texture, and surface patterns. Like Talbot's photogenic drawings, nature prints rely on the physical presence of their specimen, making that presence an active element in the method of depiction—a method based on transference from specimen to paper. Like photograms and contact prints, nature prints do not modify the specimen's original scale. But to these indexical fidelities, the nature print also adds capacities that recommend it as a superior form of illustration: it captures surface qualities which photograms tend to obliterate, and it has the benefit of easily incorporating color. The attraction of an illustrator to photograms, when indexical nature prints were probably more practical and efficacious as illustrations, cannot be explained solely by the appeals of direct, authenticating participation alone.

Where photograms seem to depart from nature prints is not in their transference of an image by means of contact, but in developing the graphic *significance* of that formative contact. A nature print is phenomenologically proximate to a natural illustration; it exemplifies less like a diagram or a drawing than like an actual specimen, an object of nature. As a copying technique, it belongs to the traditional method of rubbings, whereby one copies the texture of a coin, a leaf, a frieze, or the indentation from a drawing or inscription, by placing paper over the object and lightly, mechanically shading it with one's implement—usually pencil, charcoal, or chalk. The nature print implies (or actually involves) this indifferent regime of shading by hand, as well as the reproductive technique of lithography, so as to preserve and index the original specimen, transferring and tagging (and potentially mass-producing) its outward characteristics. But it does not translate those properties to a different, expressive medium; it does not recall the creative action of drawing in the way that photography seemed to, especially to early observers. The photogram's potential defects as an illustrator of surface detail—its monochromatic scale, its ghostly silhouetting, its glassy

texture—mark it more clearly as a contribution to the order of images. Readable as a *drawing* formed through a conjunction of specimen and medium—a "photogenic drawing," the "pencil of nature," a "heliogram" or "sun picture"—the photogram could stand at a (literal, and metaphorical) meeting point between the realm of nature and the sphere of representation. What that photographic contact created, in other words, was not a copy, a reproduction, of some existing phenomenon. Rather, by means of a strange complicity between organic growth and photochemistry, the plant converts and translates its intrinsic potentialities to the order of graphic images. The image's aesthetic aspects emerge as manifestations of those same vital powers of growth, assimilation, and organization. Even as they seemed to transcend the conventions of traditional image-making, these botanical autographs nevertheless participated in the painted and drawn world of pictorial signification.

Consider Talbot's negative contact print of the flower "Astrantia Major" (figure 1). A single stem rises from the bottom of the frame, culminating in a tight nest of leaves before branching into four thinner stems, each of which is finally capped by a rounded, flowery orb. Each of these round blossoms resembles a dandelion—a circumference of fuzzy flecks joined by a delicate frame of radial spokes to a central point—although one, larger than the other three and arching over them, is more clearly differentiated into a hemisphere of sword-like petals supporting a plume of feathery sprigs. This quartet of blossoms faintly resembles fireworks, their fluorescent rings exploding outward from four exclamatory nodes. So faint and so fine are the radial spokes tethering each efflorescence to its stem, that the luminous crescents seem disconnected and free-floating. Though the method in question requires physically flattening the specimen, forcing its flesh to lie flush with the sensitized paper, the distinct dispositions of the four blooms, combined with the variable boldness of their

supporting structures, gives an illusion of perspectival depth, as if the lower three blossoms were reaching back into the recesses of an impossible z-axis. Unlike the procedure of linear perspective, however, the effect here is the unintended byproduct of a non-optical method. The boldness, sharpness, and precision of the photographic impression depends at all points on the volume, solidity, and opacity of depicted structures. The sword-like petals of the topmost bloom, for instance, are tipped with solid white points which scale, nearer the base, to a gauzy gray, suggesting that the organic material here was delicate and partially translucent. The basal stem and the dark cluster of leaves are bold and, in outline, clearly defined, testifying to their rigidity and thickness in life. The pyrotechnic blooms owe their appearance to the fluffy clustering of tiny anthers at their rims and the comparatively vague delineation of their extremely fine filaments. In short, one *reads* the image's monochrome patterns and scales, its bold and fine lines, its vague and clear articulations, as indicators of the volume and rigidity and translucence of each part, as well as their clustering or layering in their arrangement on the plate. The image's graphic differentia code the specimen's physical properties.

Though familiarity with perspectival drawing may aid us in decoding these botanical photograms, the code itself—the significatory link between graphic detail and physical aspect—is an artifact of the method of contact printing itself. Anna Atkins's cyanotype print of "Delesseria hypoglossum" (figure 2) further exemplifies the dynamic range of this indexical-graphic code. In the central algal specimen, we see an upturned growth of four or five branches, each textured with a thicket of capillary tendrils. The detail and clarity of the image is extraordinary, the three specimens suggesting independent galaxies of interwoven filaments which, as one pores over it, generally resolve into clearly defined (if thickly and

complexly interrelated) fibers.[73] While this crystalline delineation of internal detail is the image's general theme, there are local instances of blurring at the central specimen's outer fringe. As the crisp synapses fade, at their tips, into fuzzy wisps, it is almost as if this lensless imprint were slightly out of focus. Atkins's blue-tinted photograms are, as a rule, so intensely detailed and crystalline that these instances of blur, when they do crop up, take on a complementary beauty and deepen the felt significance of the preponderant clarity. These intrusive blurs can be assessed as defects in the photograph, since these experiments are plainly concerned with reproducing intricacies as fully and as sharply as possible.[74] But besides adding to the image's tonal range and formal palette, these unchosen episodes of blurring have graphical and thematic significance. We learn to see sharpness and blurriness as indicators of how well plant and paper have bonded during exposure: where the specimen fully "fits" itself against the paper, the photograph translates this proximity into sharp and intricate delineations; where floral minutiae outstrip the paper's sensitivity, or where a structure cannot be made to "stick", we find the corresponding blur in the photograph. Our experience with this responsiveness to gradations of pressure teach us to appreciate these images as depictions, not just of a specific object, but *of contact*.

For details of boldness and blur to be legible in terms of originary contact, one needs to assume some degree of practical familiarity with the technique in question. The image does not, on its own, signify anything about contact; it does so only when we can recall or imagine the procedure of "superposition" that has produced it. But the same must be said of

[73] In analyzing this image, I have relied on the high-resolution digital scans provided on the New York Public Library's website, which allow one to magnify the image greatly.
[74] It should be stressed, though, that this differential between clarity and blurriness is *non*-optical in nature: it is not, therefore, an instance of *focal* clarity or definition. The photogram is closer to an instance of scanning, rather than of optical modeling.

any given image medium: the range of possible significance within it always involves our familiarity with its characteristic practices and with a canon of works.[75] This is why the claim made above—that these botanical photograms are images of contact—is different from observing that the image is indexical. Indexicality calls upon our knowledge of a signifier's physical proximity to its signified in order to inform us about the latter: the finger print accuses the criminal; the weathervane tells the direction of the wind. The strange significance of these botanical imprints, however, is not that they function by means of physical contact—they do not authenticate, they do not point—but that they build up our appreciation of contact as such. They enlist our (real or imagined) handling of sensitized plates and dried specimens, and connect this experience to the phenomenological contact that transpires between paper and plant; they draw a simile between our own manual depictions and the depictive power of this autonomous, automatic inscription. We feel our way over the image's graphic contours, knowing them as outgrowths and figurations of physical contact between medium and subject. Enlivened to this productive, physical congress of subject and medium, we might speculate into their deeper forms of reciprocity. To this extent, however the photogram fails to illustrate botanical appearances or teach disciplined observation, they nevertheless succeed at nurturing our imaginative intimacy with plants, perhaps attuning us to deeper principles that account for their photographic vitality.

One more graphic aspect common to botanical photograms bears mentioning: silhouetting. Silhouette drawing enjoyed a resurgence in Europe in the early nineteenth

[75] Secord, "Botany on a Plate": "the distinction [between realism and illusionism] does not reside in pictures themselves but, rather, depends on how observers balance 'sensory, perceptual, and emotional automatisms' with 'the social, the rational, the scientifically skeptical,'" 51.

century, alongside the increasingly fashionable interest in physiognomy and phrenology.[76] By tracing a person's shadow as it was thrown onto a blank sheet, one produced an indexical token for a loved one's remembrance—or alternatively, a simplified profile which the expert physiognomist could read, divining inner personality from the outward shape of forehead, nose, chin, and cheeks. While photograms fulfilled an even more dramatic reduction of fleshy presence to specular outline, this tendency was not (as previously mentioned) an advantage where botanical illustration was concerned. Silhouetting abstracted from the image a wealth of classificatory information, especially details of color and texture and volume. It also preserved peculiarities—for instance, asymmetry—that made any given specimen an imperfect representative of its class.[77] But the photogram's silhouette, even moreso than an actual shadow, testifies to the collusion of subject and medium; it speaks to the imaginative spell at the heart of botanic research. In other words, it both molds and models botanic *agency*, the capacity of an image to form (like a flower) under the influence of sunlight, for the individual qualities of one lifeform to extend themselves and organize and form qualities in a new field, viz., the field of the photographically prepared surface.

These aesthetic factors of botanical photograms, then, code the layout of the image, without, however, laying responsibility for those codes at the feet of the photographer, nor at those of the inventor of photography, nor deriving them from social convention. These qualities are a natural, unelected byproduct of the process; part of their magical appeal is that, without having been so contrived, they nevertheless allow the photogram's pictorial surface

[76] On silhouette drawing vis-à-vis physiognomy during the early nineteenth century, see Richard T. Gray, *About Face: German Physiognomic Thought from Lavater to Auschwitz* (Detroit, MI: Wayne State University Press, 2004).
[77] Maimon dilates on the significance of the photographs commitment to asymmetry, *Singular Images, Failed Copies*.

to express the creative, expressive contact that engenders it. These differential patterns—of thin and thick delineation; of blurriness and sharpness; of flat silhouetting—become readable (and, later, intentionally manipulable) features of the medium. At the same time, they present themselves as qualities reflecting the power of tactile agency as such, and especially the conductibility of botanical agency across the threshold of nature and representation. The photogram offered itself less as needful aid to scientific documentation than as a medium for making fuller sense of the lively agency at the heart of botanic phenomena. Nature appears, in this medium, not as a mechanical formula, but as a genuinely formative agency—one whose powers could teach us, through the force of analogy, about our own psychic reservoirs of creative organization; one which could also, perhaps, reach into the domain of graphical arts through *direct contact*, as well. In this poetry of intimate contact, the plant's agency could extend itself into the plantlike, yet pictorial, medium of the photogram. And it did so in its own peculiar way: automatically.

Animating Plants: Metamorphosis, Soul-Life, Time-Lapse

Early botanical photograms show how the conceptualization of photography's automatic process invoked plants both as metaphoric paradigms and as experimental subjects. In the latter case, the intimate contact between specimen and medium not only traced the plant's alluring surface qualities, but produced symbolic touchstones with which to contemplate organic nature's deeper forms of agency. These images, at their best, inspire us to think sensuously about the plant's power to assimilate and organize its environs, to calibrate form to the elegant and sustainable service of life's essential functions. After all, this power seems to extend from its own growth, sustenance, and biological reproduction, to the plane of graphic images and imaginative process. From this intimate congress with

plants, the photograph—at least at this formative stage—affects us as something quite different from a mechanical surrogate for human labor. Its whole appeal, on the contrary, is not that it performs a known task (drawing) more precisely and less strenuously than human hands, but that it involves its subject's physical presence in ways that drawing never does. The image takes form and develops in collaboration with its subject and with the agency of light, introducing unheralded graphic qualities that nourish the imagination. That is, the comparison to plants teaches us to recognize distinct forms of creativity possessed by the emergent medium of photography, rather than settling for the references to deskilled drawing or painting that soon became habitually ingrained in nineteenth-century minds.

While the early photographic complex was powerfully attuned to the formative powers and harmonic patterning of plants, it largely neglected another important fact about them: their varied forms of motility—sprouting or blooming in the secrecy of night; subtly contracting leaves in response to arid heat; extending roots into soil or angling buds toward light. The systematic study of such phenomena would develop later in the nineteenth century, thanks to the emergence of plant physiology as a discipline distinct from botany's strictly classificatory aims. Similarly, it was in the laboratory work of plant physiologists that the first time-lapse films of plant movements were made. An important anticipation of this scientific attention to dynamic plants can be found, however, in the botanical writings of Goethe—in particular, his book *On the Metamorphosis of Plants*. As discussed in the previous chapter, Goethe's romantic engrossment in nature has been a source of controversy among modern historians of science, who have energetically disputed whether he subscribed to some theory of species transmutation, whether his founding of morphology bore real

scientific fruit, whether his claim to discovering the intermaxillary bone was legitimate.[78] Though Goethe's contributions to botany are more secure by comparison, there is similar confusion regarding the exact meaning of his notion of "metamorphosis," and the extent to which the word implies any sort of actual *movement*. Did he envision the plant's transformation over the span of its life from seed to bud? Did he intuit some deeper principle of change by which extant varietals differentiated from their forebears?

The historical consensus is that Goethe did not intend for "metamorphosis" to imply physical change over time, but rather to indicate the principle by which all plants, and all parts of the plant, were intrinsically related. This sense of metamorphosis crystallized into the central discovery of Goethe's botanical inquiries: the idea that all plant structures were varied modifications of a single, primal form: the leaf. According to this interpretation of vegetable anatomy, any seemingly distinct organ—a root; a stem; a branch; a bract; a bud; a petal; or, of course, a leaf—is in essence a variation on the theme of the *leaf*. Goethe defines his notion of metamorphosis as "the process by which one and the same organ makes its appearance in multifarious forms."[79] Retrospective readers of Goethe point out that this conception of diversity based on deeper unity is not so different from the Darwinian principle of *homology*, which finds that "all lateral outgrowths are referable to one fundamental ideal structure."[80] The difference is that, while modern evolutionists explain homology in terms of common descent (the whale's flipper and a bear's paw are homologous in that they both derive from a distant mammalian ancestor), locating this "ideal structure" in the geologic record, time does not enter into Goethe's metamorphic equation. For him, the principle of

[78] See Richards, *The Romantic Conception of Life*.
[79] Johann Wolfgang Goethe, *Goethe's Botanical Writings*, trans. Bertha Mueller (Woodbridge, CT: Ox Bow Press, 1989), 31.
[80] Charles J. Engard, "Introduction," *Goethe's Botanical Writings*, 7.

variation on an archetype is based on an immediate, intuitive perception of form—just as a musically trained ear will be able to pick out the common theme at the heart of each of Bach's "Goldberg variations." Metamorphosis did not necessarily correspond to visible or historical change, but it appreciated nature's teeming variety while giving it a rational pattern, a coherence, a syntax. As Goethe put it, metamorphosis was "the key to the whole alphabet of nature."[81]

The dynamism of the organic realm meant that it was impossible to foresee the varieties nature might produce: only a mechanical process could, in principle, be predicted. Bearing intelligent, comprehensive witness to this dynamism was therefore a humbling task, as Goethe acknowledges: "it would require a lifetime to gain a panoramic view and to bring order into the infinitely free vital activity of one single natural realm."[82] The principle of metamorphosis, however, suggested an optic through which to perceive the unity governing the plant kingdom's unconstrained diversity, the common form upon which nature was constantly improvising. Discovering this metamorphic principle was itself a dynamic experience. Goethe later recounted he was initially inspired by the powers of "formation and transformation" displayed by various plants, in which he could sense "Nature and the power of imagination . . . vying with one another to see which could proceed with greater boldness and to greater lengths."[83] This "vying" between external nature and internal imagination led Goethe to conceive a method congruent to his subject: a style of observation (which he would come to call "natural observation") that synthesized poetic imagination and empirical documentation, between the associative flights of his mind's eye and his objective view of

[81] Quoted in Engard, "Introduction," 13.
[82] Goethe, *Botanical Writings*, 166.
[83] Goethe, *Botanical Writings*, 166.

the object.[84] This commitment to taking nature in and letting it mingle with one's own creative inspiration was, Goethe insisted, not only how he was able to envision the idea of the *ur*-plant, but how, so far from letting it remain an immaterial Platonic ideal, he had come to *see* it in the flesh.[85]

While Goethe's concept of metamorphosis was not temporal—it named, rather, the *principle* that natural diversity was based on a common form—his dialectical method of observation attuned him to the formal continuity that threads through a given plant's life cycle. He explains his sense for the inventiveness of plants as inspired by his observation of a particular fan palm, which displayed, all at once, a continuous scale of mature and youthful structures: "the simple, lance-shaped first leaves were still near the ground; the successive separation increased until finally the fan was discernible in complete development. From a spatulate sheath, a branchlet with blossoms finally emerged, looking like an old offspring, strange and surprising, and unrelated to the preceding growth."[86] Even though Goethe derives such importance from the fact that these distinct growth phases coexist in a single specimen, his description restores the differentiating pressure of time to it. Time is largely unavoidable in narration, but here it is clearly key to the observation itself—the time in which his attention moves from the "simple, lance-shaped leaves," through the section of increasingly separated leaves, before finally noting the blossom *emerging* from its spatulate sheath. Though the palm lies before him full grown, and though he beholds it only over the course of a day, he describes it as though it were growing, differentiating, and blooming before his eyes. In a sense, Goethe might reply that that is precisely what he saw—not,

[84] Richards, *The Romantic Conception of Life*.
[85] Goethe's insistence that he had seen the *ur*-plant is famously recorded in a conversation he had with Schiller.
[86] Goethe, *Botanical Writings*, 161.

perhaps, these phases condensed into a single motion picture, but the principle at the heart of this growth, living and embodied and inseparable from his live perception of it. This style of observation, this synthesis of perception and reflection and imagination, sustains the insight that "plant forms round about us are not predetermined and established" as in a Linnaean chart, but enjoy "a happy mobility and flexibility, enabling them to adapt themselves to the many conditions throughout the world which influence them, and to be formed and reformed in accordance with them."[87] In multiple senses, Goethe's vision of plants was an *animated* one. And this animated view is instrumental in envisioning the creative liveliness of plants, their own "desires" and strivings, their own intelligence.

The influence of Goethe's ideas—within and beyond the confines of botany, and especially among Germans—is hard to overstate. In the natural sciences, his coinage of "Morphologie" was developed into a putative discipline in the German universities over the course of nineteenth century.[88] More generally, his elevation of dynamic notions of metamorphosis, transformation, and adaptation in the study of plants and animals, helped to sow the soil in which full-scale evolutionary theories would take root. Goethe's imaginative congress with the dynamism of plants was also a central inspiration to Gustav Theodor Fechner, a somewhat ambiguous figure in the modernizing of German science. Fechner came to scientific maturity as a disciple of the nature philosophy of Schelling and Lorenz Oken—a youthful intellectual flirtation he would later partially repudiate.[89] The nature-philosophers had contended that mental and natural phenomena had to be grasped as an

[87] Goethe, *Botanical Writings*, 162.
[88] Lynn K. Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900* (Chicago: University of Chicago Press, 1995).
[89] Michael Heidelberger, *Nature from Within: Gustav Theodor Fechner and His Psychophysical Worldview* (Pittsburgh: University of Pittsburgh Press, 2004).

integral whole, not as two independent realms, and Fechner all his life remained convinced that this intuition was basically correct. Where he departed from Schelling and Oken was in methodology. Where those committed post-Kantian romantics favored private introspection as the key to grasping nature's essential unities, Fechner thought the quantitative methods of the empirical sciences would build a surer bridge between psychic and physical phenomena. Fechner formalized this position with his founding of the field of psychophysics, a forerunner to modern work in experimental psychology.[90] Psychophysics involved the quantitative measurement of psychic phenomena, determining, for example, the incremental intensities in a given stimulus required for producing a corresponding change in perceptual experiment. As Fechner saw it, such experiments supported the hypothesis that psychic and physical phenomena were linked by causal chains, and began to make sense and use of those chains, without necessarily conferring priority on the mental or the material aspect of things.

While Fechner's conception of psychophysics earned widespread acceptance among working scientists, and was vocally embraced by leading figures like Ernst Mach, his interest in nature's psychic dimensions occasionally took forms that seemed less sober and grounded.[91] In 1848 Fechner published the essay *Nanna, oder die Seelenlehre des Pflanzen (Nanna: or On the Soul-Life of Plants)*, which aroused no shortage of puzzlement among his naturalist peers.[92] *Nanna* defends the highly heterodox thesis that plants are sentient creatures; that they desire and intend and sense and *think*. Fechner makes his case, a bit

[90] Heidelberger, *Nature from Within*.
[91] On Fechner's influence on Mach, see Heidelberger, *Nature from Within*. Fechner's psychophysics was also a memorable target of Henri Bergson, who saw the whole discipline as symptomatic of an age determined to spatialize time, to partition the intrinsic continuity of duration, to externalize the ineluctable interiority of experience. See Suzanna Guerlac, *Thinking in Time: An Introduction to Henri Bergson* (Ithaca, NY: Cornell University Press, 2006), 25.
[92] *Nanna* is included in Walter Lowrie, ed., *Religion of a Scientist: Selections from Gustav Theodor Fechner* (New York: Pantheon Books, 1946).

unusually, by installing thesis of plant sentience as a starting assumption—in scientific parlance, a "null hypothesis"—then surveying in turn our likely objections to such a claim, before finally showing how each of these objections stands upon a patchwork of prejudice, error, ignorance, and unfounded assumption. One might, for example, point out that plants possess no brains, nor any other nervous tissue or circuitry, and therefore cannot be expected to perceive or reflect or cognize as humans and animals demonstrably do. But, Fechner interjects, this statement confuses a sufficient condition (a nervous endowment) with a necessary one. Empiricism teaches us that brainy creatures have sentience, not that *only* such creatures do. We are, perhaps, biased by the fact that our own experience is mediated by our brains, and therefore fail to appreciate other forms of consciousness which nature's non-animal inhabitants might, by their own distinct means, engender. As a complementary example, Fechner weighs another possible objection: that plants and flowers do not exhibit thoughtful behavior; that these vegetables are quite literally rooted in place, and cannot even *move*, much less *behave*. To this argument Fechner replies that, once again, our perception of plants shows definite bias. The world's flora may not move like we animals do, and they may not look to us as though they are moving; yet they *do*, in fact, move. Besides growing, blooming, and dying in accord with whatever plan is implanted in their seeds, their mature movements, fully perceived, can be understood as forms of intentional *behavior*. Roots, stems, and leaves all respond to external conditions and stimuli, exhibiting a definite telos: roots extend toward pockets of moisture, for the sake of drawing sustenance from them; stems extend and bend, not willy-nilly, but the better to absorb necessary light; leaves rotate, clench, and open in response to changes in temperature and moisture. Plants never fetch, roll over, or play dead, but, Fechner reminds us, they are nevertheless motile, animate, *responsive*

beings. Granted the intelligence embodied in these vegetable behaviors, the lack of a definite counterproof, and presuming mindfulness wherever we cannot rule it out, we should accordingly think of plants as possessing some form of intelligence.

Fechner, like Goethe, illustrates a line of thought in which plants strike us as mindful, as participating in the dialogical life of imagination, because of how they manifest movement. As a disclaimer, Fechner distinguishes his argument from a cultic belief that plants cognize in the ways that human beings do. They do not contemplate, dream, plan, or judge. But he allows that they own some share in the universe's psychic store—that they enjoy some sort of (largely unwitnessed) "soul life"—and later developed this panpsychic insight into the thesis of an encompassing *world* soul.[93] While Fechner's colleagues mostly declined to follow him down this speculative rabbit hole, he remained respected and admired through his psychophysical work—an avuncular figure among the "Leipzig Circle" of scientific luminaries who converged, during the 1880s and '90s, at the University of Leipzig.[94] The notable scientists living and working in Leipzig during these years included the physical chemist Wilhelm Ostwald (who warmly recalled his occasional encounters with the aging Fechner), the plant physiologists Wilhelm Wundt and Wilhelm Pfeffer, and the psychologist Hügo Münsterberg. In all likelihood, these paragons of scientific discipline would have concurred with Ernst Mach's verdict regarding Fechner's work on plant souls—that, given the latter's greatness in his professional work, he could be forgiven his somewhat embarrassing philosophical fancies. In other words, I would not want to argue that Wundt or Pfeffer or Münsterberg were invested in questions of plant psychology. But they do

[93] Heidelberger, *Nature from Within*.
[94] The Leipzig Circle is discussed in Wilhelm Ostwald, *The Autobiography*, ed. Fritz Scholz and Robert Jack, trans. Robert Jack (New York: Springer, 2017), 191-206.

represent an intellectual community in which botanical, physical, physiological, chemical, and psychological principles flowed across putative disciplinary boundaries, often combining and crystallizing in the laboratory. Fechner's investment in the soul life of plants, even if it attracted few adherents among his peers, belongs to the same intellectual brew in which these other figures distilled their own distinctive contributions. It is in this light, then, that I will examine the work of Pfeffer, and the significance of his experimentation with motion picture technology to capture the growth and movement of plants.

Pfeffer's experiments resulted in four time-lapse films that he projected during lectures to botany students.[95] These films showed, respectively, the growth and wilting of tulips (Tulipia); the constantly moving leaves of Desmodium and Mimosa (depicted side by side); the descending and spreading root structures of two fava beans (Vicia faba); and the movements of an adult flower (Impatiens), initially set on its side, as it cranes, curves, and gradually rights itself against the pressure of gravity.[96] Each of these films lasts between ten and twenty seconds; each of them adopts similar framing set-ups, reminiscent of the time-and-motion experiments of Etienne-Jules Marey. The camera frames its botanic subjects from a perpendicular angle, usually including four specimens at a time. The plants are arranged in front of a white grid, illuminated so that they stand out as dark outlines set against the plain white backdrop. The plants are, in fact, so dark that they are virtually silhouettes, giving no cues to color or volume or surface texture.[97] They almost look like

[95] Oliver Gaycken, "The Secret Life of Plants: Visualizing Vegetative Movement, 1880-1903," *Early Popular Visual Culture* 10, no. 1 (2012): 51-69.
[96] Virgilio Tosi, *Cinema Before Cinema: The Origins of Scientific Cinematography* (London: British Universities Film & Video Council, 2005), and accompanying DVD.
[97] It is not clear to what extent the darkness of the specimens is due to original lighting set-ups, or whether this impression is a product of the ageing and weathering of the film elements, or even an artifact of the digital transfer.

linear plots on two-dimensional Cartesian coordinates, their roots worming their way down into the lower sections of the Y-axis, their stems wriggling upward in a reciprocal motion.

To modern eyes, these films evoke the sober, functional aesthetics and antiseptic ambience of the laboratory—its white-tiled floors, bright and evenly-diffused light, blank impersonal walls. Pfeffer himself spoke of these films in terms of their strictly pedagogical value, however, and minimized their potential utility as an experimental apparatus.[98] Compared to photographs or diagrams, which illustrated plant growth by showing a series of static phases, these moving pictures could give students a truer impression of the plastic powers of plants. They brought home, he says, the fact that movement is a capacity evidenced not just by a few notable specimens, but is in fact integral to all plant species as such: "Since in my experience it is difficult for most students to garner a correct and plastic image of the progression of a physiological process from the contemplation of a single, decontextualized phase, these projections have . . . a high didactic value. This value is heightened by the visible evidence that in seemingly static plants lively activity is present and that visible actions and reactions *actually are possessed by all plants* . . ."[99] This fact, as Pfeffer speaks of it, seems to be something we might easily fail to grasp: plants in many ways embody our notions of stasis, our eyes see only their sedentariness; and yet, on the contrary, their essential nature consists in their dynamism. Moreover, in relying on the media of the solitary specimen, the single photograph, or a sequence of illustrative drawings, we implicitly corroborate this false impression of vegetable stasis. The movement itself remains an abstract idea manifesting itself in discrete episodes of stillness. The value of Pfeffer's plant-

[98] Quoted in Gaycken, "The Secret Life of Plants," 58.
[99] Pfeffer, quoted in Gaycken, "The Secret Life of Plants," 58.

growth films, accordingly, was in making the sensual experience corroborate the fact in question—not to evaluate static evidence of dynamism, but to see the movement itself.

Pfeffer's emphasis on sensing plant movement is not the same as positing that plants have private thoughts or experiences. But the importance Pfeffer places on movement is compatible with a liberal reading of Fechner's claims in *Nanna*. Plants might be described as "sentient" in the narrowly empirical sense that they perceive and react intelligently upon their environment—they respond to gradients of moisture, nutrition, gravity, and light, thereby demonstrating that they *sense* these environmental factors. For Fechner, this sort of dynamic responsiveness was not just a possible sign of internal mentation, but the physical counterpart to some form of psyche. Movement and mindfulness were not correlated phenomena: they were two sides of the same coin.[100] For Pfeffer, plants may not possess consciousness per se, yet their essence as beings lies in their dynamic responsiveness to a perceived world, and this essence makes peculiar demands on our own forms of perception—largely concealed from our immediate awareness, yet implicating our sensual, sympathetic recognition for their full realization. Pfeffer was, like many of his peers, a proponent of the notion of *Anschauung*—a term which translates literally as "direct visual perception," but whose full significance involves complex historical encounters between science and aesthetics.[101] *Anschauung* stressed the unity of sensual and theoretical access to natural process. In this frame, then, *seeing* plant movement is a way of bridging its natural essence to *our* psychic store, of drawing some sort of accord between the plant's essential lifeworld and our own perceptual universe. It is another take on the old question of how to reconcile psychic and physical

[100] Heidelberger, *Nature from Within*
[101] Henning Schmidgen, "Pictures, Preparations, and Living Process: The Production of Immediate Visual Perception (*Anschauung*) in Late-19th-Century Physiology," *Journal of the History of Biology* 37 (2004): 477-513.

phenoma. Seeing plant movement in a time-lapse film might not necessarily have counted as evidence of plant consciousness, but it animated these vegetable beings within our own mental frame.

Pfeffer shows little interest in unpacking the meaning of the (imperfectly witnessed) fact that plants move, or the fact that we witness this movement so imperfectly. He does not, like Goethe and Fechner, imply that plants, by their powers of movement, merit recognition as participants in the intelligent, creative, self-perceiving totality of the organic complex. Rather, Pfeffer dwells on how these obscure movements pose definite challenges to representational technique. Yet this representational hurdle seems to point to deeper, philosophical perplexities regarding the nature of movement. If plant physiology seizes upon species of movement that are deeply real, yet oddly recalcitrant to human observation, it seems to disrupt the Kantian account, in which "movement" describes the organization of human perception, not the nature of things in themselves. In claiming movement as part of their own essence, plants by the same token claim participation in the mental side of things—the mental side being the plane in which movement, as movement, exists at all.[102] The figure of the "psychic life of plants" can be taken in two (non-exclusive) ways: as an imputation that plants themselves possess some form of psyche; or as recognizing how they animate our own thoughts and dreams and worldly attachments.

The collaboration of time-lapse photography and psychic reflection in bringing plants to life (or rather: properly acknowledging the dynamic life plants already possess) indicates another affinity between cinema and plants. Bergson saw in the cinematograph an apt

[102] This is the position of Henri Bergson in *Matter and Memory*, trans. Nancy M. Paul and W. Scott Palmer (New York: Zone Books, 1990 [1896]).

metaphor for how modern, utilitarian ideologies bastardized the nature of time and movement—chopping time up into numerous abstract, static sections, then reconverting these slices into apparent motion under the power of an external mechanism, the projector.[103] The analogy of the plant, however, accords less with this general description of cinematic logic than with anecdotal accounts of the first public demonstrations of the Lumière cinematograph. The exhibitors showcased their invention by first projecting a still photograph—an image thoroughly familiar and commonplace by that time. The "miracle" began as the projectionist began to turn the crank on the device, bringing this still image to animate life.[104] Méliès recalled how the demonstration floored him; but I want to emphasize again the rhetorical force of this manner of demonstration. The miracle was not the transcription of reality's movements, not showing how a machine could survey and copy and resynthesize animate life, but in *bringing* a previously static icon, the photograph, *to life*. It was the conversion of stasis into movement, of returning the photograph to the domain (its proper domain) of movement and dynamism; a conversion which was, by the same token, of the familiar into the extraordinary, the humdrum into the ecstatic. Pfeffer's films evolved on the same logic: converting apparently static entities (plants) into dynamic ones, or rather, converting their movement from invisible to visible. This conversion reframes the character of our access to plant movement, making that access depend not on the readability of movement in its static residue, but on making the psychic appreciation of plants congruent with its object.

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[103] Bergson, *Creative Evolution*.

[104] This Exhibition strategy is discussed in Tom Gunning, "An Aesthetic of Astonishment: Early Film and the (In)Credulous Spectator," *Film Theory and Criticism*, ed. Leo Braudy and Marshall Cohen (New York: Oxford University Press, 2007).

Plant-growth films, like early botanical photograms, are images whose scientific value is inseparable from their psychic power. In both cases, the images fascinate because they call upon our awareness of their own mode of formation, make us feel the dynamic formative powers of the plants on display, and invite our imaginations to ponder questions of formation and creation as they touch the lives of plants as well as our own. They are not just externally wrought figurations or illustrations of botanical agency, but aesthetically articulate forms, iconically communicative, whose graphic minutiae manifest organic processes. In the case of the photogram, we have discussed how these epistemically pregnant registers include the variable boldness and transparency of lines; more or less dramatic blurring; and silhouetting—each of which characterize the correspondence between natural object and photographic method, construing correspondence through the modality of physical contact. In the case of time-lapse images of plant-growth, meanwhile, the aesthetic registers that immediately present themselves are the *completeness* and relative *smoothness* (or jerkiness) of apparent motion. Indeed, for early motion pictures of all sorts, these two criteria (as well as the annoyance of flicker) were recurring technical impediments for viewers making aesthetic sense of the new medium. In the case of plant-growth films, however, these aesthetic factors were laced with deeper epistemological significance. Teasing out this significance, we can shed new light on how silent-era theorists began to rethink film's automatisms in an organic, putatively ecological frame.

Smooth Motion and Cinema's Organic Automatisms

The ideal of *Anschauung* clarifies the epistemological value of Pfeffer's plant-growth films. By sequentially photographing the phases of a given plant's growth and behavior, then reprojecting that sequence using cinematic technology, he could, in several senses, bring

these sedentary beings to life. Just as the cinematograph animated static, photographic records, Pfeffer's films animated static plants; and in representing their intrinsic powers of movement, he constructed an occasion in which his students could directly perceive this dynamic principle. To call this perception "direct" might seem paradoxical or contradictory: after all, the movement in question was constructed by laboratory protocols and mediated by a technological apparatus. Yet there was a sense in which the "thing" rendered on the cinema screen—not the flesh of the plants but their *movements*—was precisely the phenomenon one wanted to witness. Movement was fundamental to the emerging sciences of the nineteenth century, elevating physiology over anatomy and, by the same token, plant physiology over botany. To study the dynamism of plants only by reading textual accounts and sequential illustrations, without ever beholding the thing itself, would produce an incomplete, partially amputated form of knowledge.

Indeed, the diverse, preparatory stages of research, experiment, and theory leading up to the Lumières' demonstration of motion picture photography, have long served as mythic waystations in the story of cinema's emergence. Canonical histories, from Ramsaey to Rotha to Sadoul to Thompson and Bordwell, routinely rehearse the scientific breakthroughs that paved the way for cinematic art, but which did not conceive the goal of "motion picture photography" per se: Plateau's research on retinal afterimages; the apparent motion produced by "philosophical toys" like phenakistoscopes and zootropes; the invention of photography and the reduction of its exposure speeds; the popular projected light displays of magic lanterns and phantasmagoria; the use of chronophotography for analyzing vital movements; and finally, the slight nudge that turns chronophotography into cinema by re-projecting the latter's partitions on a celluloid film strip. While such histories frame motion pictures as an

unintended byproduct of laboratory research, or else as an unexpressed, largely unconscious impulse (the "myth of total cinema" that Bazin identified as the animus of Georges Sadoul's film history), Jimena Canales contends that something like cinema was, in fact, often explicitly envisioned and attempted by these same "pre-cinematic" researchers, and that they did so precisely because representing movement was so important to the sciences.[105] Jules Janssen, for instance, framed his chronophotographic revolver as "the phenakistoscope in reverse," confident that its sequential analysis of celestial transits could be restored to movement for the benefit of astronomers. Etienne-Jules Marey, often portrayed as skeptical of cinema, nevertheless saw resynthesized movement as a valuable check on his analytic studies of animal locomotion.[106] Technical obstacles, rather than a lack of interest or desire, are what prevented these researchers from developing motion pictures for scientific use.[107]

One of the major technical hurdles concerned the smoothness of apparent motion when a chronophotographic sequence was reprojected. Serial photographs tended to distort their subjects, which made them serve poorly as animation cels: the result was a halting, stuttering, fragmentary succession that failed to congeal into a continuous gesture.[108] Some, like Muybridge, circumvented this defect by manually transcribing a series of *representative* photographic frames to a film strip, discarding others, and "correcting" the optical distortions introduced by each photographic snapshot, thereby ensuring a smoother display during projection. This reversion to manual intervention falls short of the automatism that

[105] Jimena Canales, "Desired Machines: Cinema and the World in its own Image," *Science in Context* 24, no. 3 (2011): 329-259. See also Scott Curtis, *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany* (New York: Columbia University Press, 2015), on the variable uses and affinities that made researchers turn to cinema as instrument or metaphor.
[106] Also those scientists mentioned by Schmidgen, "Pictures, Preparations, and Living Process."
[107] Canales, "Desired Machines."
[108] Canales, "Desired Machines."

differentiates photographic cinema from hand-drawn animation. But the logic of such an intervention reveals the significance of *smoothness* as a quality of phenomenal movement. The quality of smoothness measures our awareness of the apparatus, of the extent to which our experience of the phenomenon seems mediated or engineered. In other words, the smoother the apparent motion in a scientific film, the more we feel ourselves to be in the live presence of, to perceive all at once for ourselves, the dynamic phenomenon it portrays.

This epistemological value attached to the liquidity of movement speaks to a vanishing horizon between the scientific significance of time-lapse films, especially as their practitioners became more proficient at projecting these movements smoothly and continuously, and the range of meanings and associations they aroused among viewers primarily interested in film's aesthetic viability. Film theorists of the 1920s frequently invoked examples from scientific films in order to substantiate the medium's exalted vocation. Microcinematography, X-ray cinematography, and slow-motion all featured reliably in these accounts as proofs that the motion picture did much more than reproduce the world of everyday experience. References to time-lapse photography are continuous with these other prized effects, often placed in a litany of such examples. Discussions of plant-growth films, however, inspire flights of peculiar eloquence, in which the nature of the medium as such is interrogated in relation to the botanic lives it discovers. The novelist Collete exemplifies this film-critical motif when she describes a "'fast motion' documentary" showing the germination of a bean: "At the revelation of the intentional and intelligent movement of the plant, I saw the children get up, imitate the extraordinary ascent of a plant climbing in a spiral, avoiding an obstacle, groping over its trellis: 'It's looking for something! It's looking for something!' cried a little boy, profoundly affected. He dreamed of a plant

that night, and so did I."[109] Collette evokes the appeal of the cinematic medium by highlighting the dramatic life it breathes into its vegetable protagonists, which radiates through the exhibition space, triggering intuitive mimetic responses, and seeping even into the dreams of the assembled participants. Cinema's contagious effects had been often remarked, but seldom so approvingly. Here, the medium figures as relay between the purposeful demonstrations of nature and their nourishment of human, imaginative appetites—a use not so distant from the scientific paradigm of visual instruction.

For other French writers on cinema, the spectacle of growing plants served a more definite theoretical agenda. For Jean Dréville, it was among the subjects which showed most clearly cinema's status as a documentary medium, a lens clarifying the natural world rather than an implement for writing fictions.[110] Jean Epstein similarly emphasized the moving image's inherent truth-telling functions, invoking Louis Delluc's famously elusive notion of *photogénie* to explain the moving image's unique power to discover and magnify invisible dimensions of physical reality. Such revelations often fused psychology with the spectacle of movement as such. Through "fast motion," Epstein writes, everything comes alive: "Crystals become larger, growing one on top of another, smoothly uniting out of something like sympathy. . . . And the plant which bends its stalk and turns its leaves toward the light; isn't what opens and closes its corolla, what inclines its stamen to the pistil, in fast motion, precisely the same quality of life in the horse and rider which, in slow motion, soar over the

[109] Colette, "The Cinema," in Alain and Odette Virmaux, eds., *Colette at the Movies*, trans. Sarah W. R. Smith (New York: Ungar, 1980), 61. Quoted in David Lavery, "'No More Unexplored Countries': The Early Promise and Disappointing Career of Time-Lapse Photography," *Film Studies*, Issue 9 (Winter 2006), 1.
[110] Jean Dréville, "Documentary: The Soul of Cinema," in Richard Abel ed., *French Theory and Criticism*, 2.42-5.

obstacle, pressing close to one another?"[111] Botanical movements were apt examples of the new medium's most specific powers—whether the plasticity prized by art critic Élie Faure, the Einsteinian fusion of space and time in a single continuum, or the photogenic pulsations of the cinematic lens, properly trained, can recover from nature's apparent stasis. These essential qualities of the medium address the imaginations of film spectators while intimating a psychic dimension, a primal animism, in organic nature.

Germaine Dulac was especially eloquent in integrating the behaviors of time-lapsed plants into her theoretical statements on film, especially her appreciation for the language of visual music effected by film, alongside dance. In her own film *Theme and Variations* (1928), she illustrated these associations through dissolves that reveal graphic and dynamic matches between plant growth and balletically danced movements. The aesthetic pleasure of these visual rhymes speaks not only to common mechanics, common organic musculatures, but to a deeper common psychology. A time-lapse film of growing wheat not only analyzes and measures the empirical fact of vegetable movement, but presents these movements as a suite of graceful and coherent gestures, a "series of minor rhythms which accomplish the major rhythm," so that "we will no longer have only the synthesis of the movement of growth, but the psychology of this movement. We feel, visually, the painful effort a stalk expends in coming out of the ground and blooming. The cinema makes us spectators of its bursts toward light and air, by capturing its unconscious, instinctive and mechanical movements."[112] Vision, in this account, is already a compound, synesthetic faculty, interfused and shaped by overtones of music (especially rhythm), kinesthetic sympathy

[111] Jean Epstein, "*Photogénie* and the Imponderable," in *French Theory and Criticism*, ed. Richard Abel, 2.189-90.
[112] Germaine Dulac, "From 'Visual and Anti-Visual Films," in *The Avant-Garde Film: A Reader of Theory and Criticism*, ed. P. Adams Sitney (New York: New York University, 1978), 32.

(dance), and touch. Bearing witness to the elegant dances performed by plants, their visual movements and rhythms, "brings us into contact with a complex life"—which contact takes the form of psychological recognition.[113] We perceive the movements of plants as manifesting their own private *efforts*, in accord with their own unconscious *psychology*. And we perceive this, specifically, through the hybrid modality of *feeling, visually*.

Such intimations of the plant kingdom's "optical unconscious" were, perhaps, typical of a more general penchant for animistic claims among French theorists of the era. But they recur, as well, in texts that are less invested in such miraculous revelations. In *Film as Art*, Rudolf Arnheim focuses on those techniques by which filmmakers articulate a unique aesthetic language. Yet when he comes to describe the "Kulturfilm" *Das Blumenwunder* (1926), his ecstatic description echoes Dulac: "The swaying rhythmic breathing motions of the leaves, the excited dance of the leaves around the blossom, the almost voluptuous abandon with which the flower opens—the plants all at once come alive and show that they use expressive gestures like those to which we are accustomed in men and animals. Watching a climbing plant anxiously groping, uncertainly seeking a hold, as its tendrils twine around a trellis, or a fading cactus bloom bowing its head and collapsing almost with a sigh, was an uncanny discovery of a new living world in sphere in which one had of course always admitted life existed but had never been able to see it in action. Plants were suddenly and visibly enrolled in the ranks of living beings. One saw that the same principles applied to everything, the same code of behavior, the same difficulties, the same desires."[114] Arnheim's commitment to the sciences of psychology and aesthetics makes this passage surprising. It is

[113] Dulac, "Visual and Anti-Visual Films," 32.
[114] Arnheim, *Film as Art*, 136.

one thing to indulge an anthropomorphic metaphor—the "breathing motions," "voluptuous abandon," "excited dance," and collapsing "sigh" of various plant movements—for the sake of poetic tone. But Arnheim seems to pursue his poetic license to the point of drawing a cosmic moral: that we, plants, and our other organic companions all share the same "code of behavior, the same difficulties, the same desires." The marvelous beauty of this film *demands* description in these anthropic terms: to seek more objective ones would be vain and misleading with respect to our perceptual experience. The truth of this perception, in turn, argues on behalf of the thesis of panpsychism. Our sense for plant psychology comes not at the end of a well-ordered deduction, but in an immediate, self-enclosed perception; and to perceive that psychology is in some sense already to confirm its reality: its being consists in being perceived.[115]

Time-lapse techniques, especially when they animated plant life, helped these theorists to identify cinema's inherent habits and powers. These inherent powers, moreover, occasion equally specific forms of spectatorship—an intense, holistic, dynamic perception that largely corresponds with the observational ideals conceived by romantic scientists of the nineteenth century. Goethe's notion of metamorphic plants; Fechner's thesis of mindful ones; Pfeffer's focus on plant movement: each of these moments in botanic science conceived their object as inextricable from the quality of the scientist's perception of it. Knowledge of nature depended, not on the technical transcendence of the embodied, fallible witness, but on a creative attunement of the observer's organic sensibilia to the liveliness of their object. The nature of the thing itself was bound up with the humane terms in which it was observed—one could not form a true idea of dynamism without seeing the movement

[115] A modification of Bishop Berkeley's empiricist dictum *esse ist percipi*, "to be is to be perceived."

immediately, with one's own eyes, and with all the anthropomorphic associations (painful striving; anxious seeking) that inevitably percolate into that perception. In this sense, time-lapse's charactering of the cinematic medium went hand in hand with how it modeled romantic ideals of natural knowledge: in ministering to the ideal of *Anschauung*, it promoted an association between the sort of thing cinema was and the sort of things it revealed plants to be.

Conclusion: The Birth of a Flower

We have seen how early theoretical statements on film often took for granted (or hedged against) the medium's entanglement with industrial capitalism, and with modernity's typical mechanical avatars. To take motion pictures seriously on aesthetic terms, one first had to excuse or discredit their resemblance to other mechanized industries, and to other artless duplication devices—to show that the photoplay did more than "can" theater, that its cultural value went well beyond the automatism of the organ grinder. Only then could one credibly argue that filmmaking involved its own aesthetic language, that it was a distinct means of creation, that it obeyed the directives of its author, and that its products rewarded specific forms of aesthetic attention. This aesthetic apology for film's automatism involved, unconsciously or by design, a diagnosis of mechanization's systemic influence, occasionally yielding the hope that cinema, a machinic art, was perfectly poised to reveal and contest the future of the machine age.

In many ways, the technical features that specify time-lapse photography count as intensifications of cinema's component automatisms. Where commercial films were, during filming, responsive to the manual exertions and improvisations of the camera operator—whether by winding the crank, adjusting focus, panning or angling or repositioning the

camera during an individual shot—time-lapse techniques minimized these interventions, managing the film speed by means of clockwork, and severely limiting options for manipulating the camera once it had been set up. And yet, when this inhuman gaze captivated the growth and efforts of plants, it embraced symbolic overtones from the sphere of organic nature—especially the sense in which that sphere possesses its own distinct, creative, purposeful energies. Cinema as such is enriched from this association: just as the romantic poet took inspiration from vegetative principles of unconscious production, so the film theorist could develop and exploit aesthetic criteria (whether Epstein's *photogénie*, Dulac's visual music, or later, Bazin's and Kracauer's photographic realism) suggested by, and often troped in terms of, the formative powers of plants.

I want to conclude this chapter by considering how the aesthetic features of early plant-growth films illustrate these tensions between film's mechanical and organic attachments. A decade into the twentieth century, the British naturalist F. Percy Smith produced a film of lasting, deceptively simple beauty: *The Birth of a Flower* (1910). We can appreciate this film as an inheritor of Pfeffer's scientific studies of tulips and mimosas, noting how both films employ time-lapse photography to display several botanical species growing before our eyes, while also underlining the aesthetic differences that distinguish these two works. Whereas Pfeffer maintains frontal framings capturing the whole specimen, from leaf-tip to radical, Smith frames his subjects from closer, partial, more dynamic angles; where Pfeffer's images show little tonal gradation between stark black and white, Smith's employ an early color process that gives red and pink hues to his blossoms; where Pfeffer's plants mature and branch in skips and stutters, Smith's open themselves to us in elegant, liquid gestures. In each case, we might chalk these differences up to distinct institutional

sources and audiences, or to the march of technical progress, or to the popular domestication of time-lapse imagery. Pfeffer's films were artifacts of scientific research, after all—born in the laboratory and projected in the lecture hall—whereas Smith was only an amateur naturalist tinkering with photographic equipment, whose principal ambition was to delight a lay public with aesthetic marvels, sampling the sheen of natural science, perhaps, but in no sense plumbing its depths. *The Birth of a Flower*'s aesthetic advances, its refinement in color, shading, framing, and above all smooth motion were, we might say, of purely ornamental value. We might also observe that these aesthetic values, especially the preference for smooth motion over intermittent stuttering, are machinic in origin—based, that is, on the modern engineer's quest for efficient and streamlined performance, and effected through the time-lapse photographer's design and refinement of the photographic apparatus.[116]

But the smooth and striking movements communicated in Smith's film might be read differently—as, on the one hand, highly pertinent to the epistemic substance of the film, and as expressing a vital, not mechanical, connection to its floral subjects. In short, the smoothness of the movements we see is less a sign of the filmmaker's technical dominance over natural subjects, than an index of attunement between craft, vision, and botanical process. The technical challenges Smith faced involved the careful control of filming conditions—maintaining consistent light levels for each successive exposure; determining in advance a single view point that could showcase a given specimen's most impressive evolutions; and calibrating a mechanism that could take successive exposures at precisely

[116] Mumford identifies a series of aesthetic values that were introduced by the example of efficient, simple, and effective machine designs. *Technics and Civilization*.

spaced intervals, over several days and without human supervision. But these controls over the filming environment had constantly to refer to the autonomous nature of their subject, accommodating themselves to how, where, and when a given plant was inclined to move. Most critically, the rate of exposure had to accord with the temporal growth pattern of the specimen—rapid enough that it would not miss a key phase in the plant's movement (which gap would produce a hiccup or jump during projection), but gradual enough to convey the drama and dynamism of the plant's life cycle holistically, in a single, perceptible flourish. "Any moment whatever" could suffice when filming live actors at twenty-four frames per second, but when filming the growth of a plant, one had to be choosier in subdividing time: some moments were more important than others, and finding the *right* filming speed involved both calculation and sensitivity.

The smoothness of motion in Smith's film can spark in us an appreciation for how well the film technique has attuned itself to the physiological specificity of each flowery performance. Smoothness of time-lapse motion is an index, an analogical register, of the quality of this attunement of cinematography and plant behavior. It demands a *non*-arbitrary form of clockwork, and it impresses upon us, not necessarily the ingenious manipulations of the cinematographer, but the fruitful correspondence of craft and subject—the creative and thought-provoking power of this technical harmony. In Smith's case, he came to this creative cooperation with his botanic subjects by employing a decidedly pre-industrial technology: a water-clock.[117] The smooth movement we see, and the pleasure we take in it, don't necessarily reflect the industrial, rational, reproductive logics of modern capitalism, but

[117] Discussed in Frederick A. Talbot, *Practical Cinematography and its Applications* (London: William Heinemann, 1913), 126.

rather allegorize a different economy of technics and nature and artistic creativity.[118] Intimately attuned to the plant's habits of growth, the beauty of the flower's periodic blooms, the film folds us into an immediate perception of these other forms of genius, of unconscious intelligence, while by the same token renewing and reanimating the symbolic significance our botanical companions hold for us. Besides being good for eating and pleasing to look at, plants, these films remind us, are often good for thinking with. Or, as Dulac put it, "Flowers, whose stages of life appear to us brutal and defined, birth, blooming, death, and whose infinitesimal development, whose movements equivalent to suffering and joy are unknown to us, appear before us in the cinema in the fullness of their existence."[119]

[118] Mumford outlines the coming of the "eotechnic" period in the last chapter of *Technics and Civilization*.
[119] Germaine Dulac, "The Essence of the Cinema: The Visual Idea" (1925), 39.

Figures:

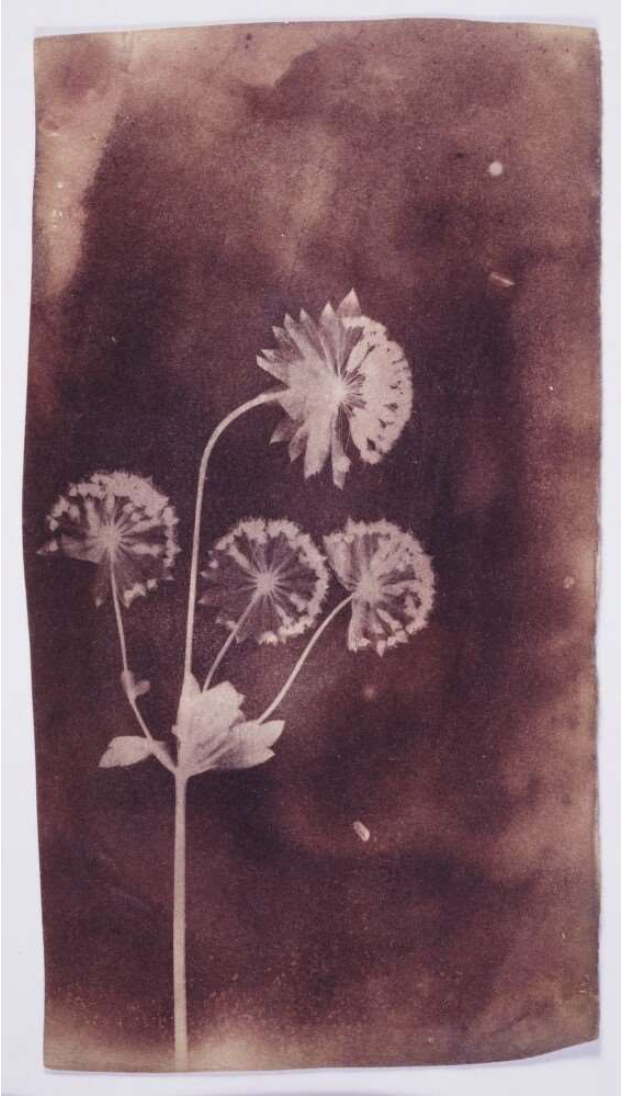

Figure 5: William Henry Fox Talbot, Botanical specimen with flowers and stem, Astrantia Major*, 1838, Royal Photographic Society Collection*

Figure 6: Ann Atkins, *Delesseria hypoglossum*, 1853, New York Public Library

Chapter 4:

Filming at the Speed of Life: Urban Rhythms, Experimental Impulses, and Organismic Vision

If we were to survey the development of time-lapse aesthetics in the decades following Smith's *Birth of a Flower* (1910), Godfrey Reggio's *Koyaanisqatsi* (1982)—a technically provocative, epically scaled, poetically rendered evocation of ecological despair—would stand out as a milestone and transition point. With virtually no verbal commentary, the film accelerates scenes of urban activity to illustrate a frenetic, robotic way of life that is "out of balance" because it is out of synch with the cyclical rhythms of Earth.[1] We are treated to a visual, visceral sermon on the state of our technological detachment from the planet's self-renewing ecosystems, and how the global spread of capitalist infrastructures has dispatched ancient and sustainable styles of dwelling. This message is sobering to the point of bleakness, yet it is not without ambiguity. It has been noted that the urban time-lapse footage in *Koyaanisqatsi*, considered on its own, is stirring, emotionally captivating, and beautiful in ways that seem to undercut the film's environmentalist lament.[2] In one remarkable section, the camera speeds across the Bay Bridge in a handful of seconds (a

[1] The film's subtitle, "life out of balance," is supposed to approximate the meaning of the Hopi word, "koyaanisqatsi."

[2] MacDonald comments that "in a number of other films of city life that use extensive timelapse shooting," a critical message is likely to be "overwhelmed by the frequently magical effects of time-lapsing itself" because "time-lapsing generally charms the eye into an appreciation for the degree to which the systematic processes of the city *do* function." *The Garden in the Machine: A Field Guide to Independent Films about Place* (Berkeley: University of California Press, 2001), 168.

ludicrously intense "phantom train ride"), spastically careening into the heart of San Francisco's financial district. In other scenes, the camera portrays the city in ways that channel traditional landscape aesthetics, steadily panning across the Los Angeles cityscape gaping below, as if to contemplate the myriad streams of headlights streaking through the avenues below. These images are so technically refined, so majestic and astonishing in their effect on the spectator, that it is worth asking whether this aesthetic pleasure is after all compatible with the ethic in which the film is supposed to be instructing us.[3] If these images corroborate the notion that modern civilization has gone off the rails, why are they so intuitively appealing, so gripping, so viscerally moving?

In utilizing time-lapse aesthetics as an implement of sociopolitical commentary, *Koyaanisqatsi* suggests a counterpoint to the earlier, scientific contexts of time-lapse visualization that have been considered in the previous chapters. If time-lapse techniques were first refined in contexts of scientific research, education, and popularization, these examples were brief and topically focused, isolating the object or phenomenon under scrutiny and holding it in an intense, unwavering gaze. In the case of *Koyaanisqatsi*, however, time-lapse photography is varied and elaborated through the entirety of a feature-length film, helping to compose a synthetic, synoptic vision of the face of modern life. In short, Reggio's film is an experiment in integrating time-lapse footage into a coherent *text*,

[3] Matthew Bell describes this schism as "an aesthetic that exceeds and complicates [the film's] apparent thematic simplicity. . . . The real novelty of *Koyaanisqatsi* is the way it stretches and condenses time, an aspect that remains more startling and strange in 2013 than does the film's environmentalist critique." Bell, "Inhuman Temporality: *Koyaanisqatsi*," *Bridgewater Review* 32, no. 1 (2013), 20. It is worth pointing out that Reggio welcomed the idea that his imagery was somewhat ambiguous, and that one of the film's key collaborators—cinematographer Ron Fricke—does not seem to have shared Reggio's philosophical vision. See Scott MacDonald's interview with Reggio in *A Critical Cinema 2: Interviews with Independent Filmmakers* (Berkeley: University of California Press, 1992), 378-401.

coupling this device's effects with cinema's expressive resources, and weaving its technical protocols together with the formal grammar of cinematography.

Koyaanisqatsi is a hybrid text, representing an unusual accommodation between Hollywood and experimental film: a poetic, nonnarrative meditation on the affective textures of postmodernity, with a considerable budget, theatrical circulation, an original score by a major composer (Philip Glass), and a roughly 90-minute running time.[4] The film also raises broader questions about relationships between film and "experiment," especially about the affinities, exchanges, and distinctions between, on the one hand, film *as instrumentalized for scientific research*, and on the other, the artistic priorities of a cohort of "experimental" filmmakers working in North America. For this latter group, the term "experimental" was sometimes used interchangeably with "avant-garde" or "underground"; at times, it was invoked to distance independent American filmmakers from association with the European avant-garde; but it was also a way to signal a significant and generative relationship between artisanal filmmaking and the experimental sciences.[5] In this last connection, the term "experimental" spoke to the feeling that film artists were experimenting with the medium itself, rejecting its conventional uses and grammar as established in Hollywood fictions, and exploring its alternative possibilities: artisanal production instead of the industrial assembly-line, personal expression rather than genre-bound storytelling, foregrounded formal elements instead of the concealments of an "invisible style."[6] Often, experimenting with the medium

[4] Scott MacDonald, "Interview with Godfrey Reggio."
[5] Several recent publications directly confront this relationship. See Oliver Gaycken, "'Beauty of Chance': *Film ist.*," *Journal of Visual Culture* 11, no. 3 (2012): 307-327; and James Leo Cahill, "Hors d'oeuvre: Science, the Short Film, and *The Perception of Life*," *Framework* 52, no. 1 (2011): 66-82.
[6] On the valances of the term "experimental," see the essays in P. Adams Sitney, ed., *Film Culture Reader* (New York: Cooper Square, 2000); and David E. James, *Allegories of Cinema: American Film in the Sixties* (Princeton, NJ: Princeton University Press, 1989).

meant concretely tinkering with camera and editing techniques in ways starkly at odds with Hollywood protocols. To be an experimental filmmaker was to reject Hollywood, but also to pledge an affinity for the ideal of the objective researcher, the purity of his or her labors. At times, it meant borrowing iconography from research films. Consider Bruce Conner's use of ballistics experiments in *A Movie* (1958) and of nuclear test footage in *Crossroads* (1976); Marie Menken's reworking of sperm microphotography in *Hurry! Hurry!* (1957); or Tony Conrad's repurposing of stroboscopic "flicker" effects in *The Flicker* (1966).

These citations and borrowings exemplify a bit of conventional wisdom: that the native soil of scientific iconography is the laboratories and theories and research agendas of the researchers who first make use of them, and that the epistemological value of these images is evacuated when they are subsequently appropriated by artists. But in this case, the attraction of filmmakers to scientific films also attests to a vital recognition that science had something to tell artists about the nature and capacities of their medium, about the range of things that motion pictures could be and do. On the one hand, in restaging scientific iconography, accentuating its aesthetic possibilities, these artistically conceived films could also reframe and reanimate the epistemological axes of the sciences. On the other hand, what these artists rediscover in "found" scientific footage is an unconscious, experimental inquiry into the nature *of film*. The short films in Gustav Deutsch's *Film ist.* (1998) make this latter point vivid: they remind us that experiments that *use* film (to analyze, say, the locomotion of a cat) are also inquiries into the nature and beauty of film itself, part of a tradition that "finds in utilitarian imaging a powerful resource for generating aesthetic revelation."[7] Filmed experiments exemplify one of the medium's original and enduring uses, and effectively

[7] Gaycken, "'Beauty of Chance'," 319.

probe film theory's foundational questions: what film *is*, what it is *for*, what sorts of phenomena it is *like*, and what sorts of things it is *attracted to*. Jean Painlevé famously put this same point more succinctly: "It never would have occurred to the pioneers of cinema to dissociate research *on* film from research *by means of* film."[8] To put this more generally, to inquire *by means of* a medium is also, whether we realize it or not (and scientists often did realize it), to inquire into the *nature* of that medium. This early and instructive imbrication of film and experiment is, I would suggest, behind the artistic efforts of North American experimental filmmakers as well. It is central to what I will characterize as the experimental *impulse* that animated the work of that community and its forebears.

In this chapter, I will consider the significance of this experimental impulse in connection with the sophisticated time-lapse effects one finds in *Koyaanisqatsi* and in earlier cross-sectional city films, or "city symphonies." In Reggio's iconic film as in earlier cinematic portraits of urban life, the camera operator's tinkering with time-lapse effects counts as a doubly creative gesture: the filmmaker explores her urban environment at the same time that she resolves concrete technical problems and finetunes the apparatus; she interrogates her medium by exploring the city with it. It turns out that tinkering, as an impulse to artistic experiment, has much in common with early uses of film to study tissues, germs, cells, and other biological phenomena, where scientists had similarly tested the powers of this new medium while studying life's unstill building blocks. This dialectic between tinkering with the cinematograph, and exploring by means of it, is critical to the film that I will focus on in this chapter: Hilary Harris's *Organism* (1975).

[8] Jean Painlevé, "Scientific Film," quoted in Hannah Landecker, "Microcinematography and the History of Science and Film*," Isis* 97 (2006), 121.

Commentary on *Organism* rarely neglects noting its resemblance to *Koyaanisqatsi*.[9] Both films rely on time-lapse effects extensively, and both use the technique to orchestrate an encompassing, panoramic portrait of modern life—a portrait which urges commentary on the relationship between nature and industrial society in the late twentieth century. These two films treat similar subjects, employ the same techniques, and even share some footage[10]—and yet they evoke strikingly different emotional responses, and they seem to articulate contradictory messages. Where *Koyaanisqatsi* shows us modern technology dominating and stamping out the last flickers of sustainable life, *Organism* tells us that our social and political infrastructures coalesce in a natural harmony. For all that they "look" so similar, these two films present irreconcilable *visions*.

In comparing *Organism* and *Koyaanisqatsi* in this way, we assume an underlying, theoretical distinction between message and aesthetics, content and form. This vocabulary encourages us to think of a documentary's message as more or less pre-formed, and of its technique as a means to articulating that message and presenting it persuasively to an audience.[11] What is interesting about *Koyaansiqatsi* and *Organism*, however, is not what their respective filmmakers might have meant to *say* about nature, modernity, and technology, but how they use to film to *problematize* our usual conception of our social world, and our assumptions about the social's enmeshment in a "natural" environment. In my reading of *Organism*, I will begin by considering how the film instrumentalizes time-lapse techniques, how it uses these effects in unison with other rhetorical devices to drive

[9] Scott MacDonald, "Interview with Godfrey Reggio."
[10] At least one shot—of a newsstand's dwindling stack of newspapers—is duplicated in both films. Reggio ("Interview with Godfrey Reggio") also states that Harris contributed additional photography of New York for *Koyaanisqatsi*.
[11] Bill Nichols has made rhetorical tropology central to his theorization of documentary. See Nichols, *Representing Reality: Issues and Concepts in Documentary* (Bloomington, IN: Indiana University Press, 1991).

home the point that New York City is organized like a living body. I will then complicate this provisional reading by considering the film's generic and institutional sources—namely, its relation to earlier "city symphonies" and its debt to early films of biological phenomena. Highlighting the experimental impulse that is indexed in these city films, as well as time-lapse photography's entanglement in biology's paradigm disputes and disciplinary gazes, I sketch an alternative account of the *Organism*'s message and aesthetics. What is at stake in this film is not so much an articulable thesis (an argument that could be summed up just as accurately, if not as impressively, in words) as a *way of seeing*. *Organism* is rooted in the impulse to tinker in-camera with time-lapse effects, thereby yielding formal discoveries and aesthetic insights—insights which in turn defamiliarize our social-technological environment and foster a critical relation to it. The film formally models and engenders a way of seeing that could be called *organismic*. In the spirit of open-ended experimentation, I will conclude the chapter by hypothesizing about the nature and significance of this sort of organismic vision.

Form, Function, and Organism in *Organism*

Filmed over roughly seventeen years, and with a running time of just under twenty minutes, *Organism* offers a brief, poetic portrait of New York, experimenting with ways to capture the city's hustle and bustle, and stressing its varied but integrated subsystems.[12] The film is at once a study of the city, a celebration of its diversity, and an affirmation of how this

[12] In a March 1973 interview with Robert Gardner, for the latter's television program *Screening Room*, Harris notes that he began shooting in 1958. The film, in its current form, was not screened until 1975. In this ratio of shooting time to screen time—each minute of *Organism* corresponding to nearly a year of filming—the film might be thought of as embodying the time-lapse-esque logic of longitudinal films (like Michael Apted's "Up" documentaries [1962-], or Richard Linklater's *Boyhood* [2014]).

diversity supports a unified expression of *life*. Indeed, the film seems to defend the thesis that the city itself is a vast but coherent life form, an organism whose self-sustaining subsystems all contribute to a greater whole—perhaps even a distinctly *American* unity composed of many diverse individuals. Taking the film as an argument about the nature and make-up of the (American) city, what role do the film's technical virtues and formal structures play in corroborating this speculative thesis?

The film's structure divides roughly into three main sections, or movements. Following a brief, evocative montage previewing the visual and acoustic elements that will be developed in the rest of the film—an operatic overture, of sorts—the first main section presents the city's discrete systems through a form of *anatomy lesson*. Sped up images of different urban systems (parcel delivery, construction and demolition, waste disposal, vehicular traffic, switchboards and telephone wires) are "explained" by tinny offscreen voices that seem to have been sampled from very dry medical school lectures. An early sequence shows the offloading of shipping containers, which are placed onto big rigs and freight trains; this fleet of delivery trucks disperses into the urban interior, distributing identical cardboard boxes to stores and office buildings. We then see indoor time-lapse shots of the ant-like commotion around a cafeteria buffet, garbage trucks dumping their loads in large trenches, large hydraulic machines scooping this waste onto barges, which carry this material off the island. According to the dispassionate medical voice-overs, this nutritive circuit—usable material filtering into Manhattan as packets of waste flow out of it—parallels the body's cycles of digestion, metabolism, and excretion. Throughout its opening section, the film insists on this same conceit—captioning city footage with offscreen medical discourse—to paint a series of systematic analogies: sewers manifest the same logic as the

body's immune system; construction work resembles tissue regeneration; traffic jams, like the overproduction of red blood cells, can be understood as a pathology of an otherwise well-tempered circulatory system.

Following this comparative anatomy of the city's internal systems, *Organism*'s middle section moves away from the lecture-hall form of address, employing more poetic strategies for evoking socio-biological analogies. As the ghostly chorus of lecturing voices fades out (though these voices return intermittently through the remainder of the film), David Hollister's electronic musical score becomes more prominent, mirroring the pace and cadence of Harris's images. The music is reminiscent of mid-century science fiction soundtracks: ethereal whirrs of a glass harmonica, stuttering and off-kilter beats, droning synth horns punctuated by irregular bursts of blips and beeps, intermittent arpeggios that rarely settle into a repeatable theme or chord progression.[13] Coupled with Harris's time-lapse studies of the city's enclaves, the music seems to frame our disembodied perspective as belonging to extraterrestrial tourists, scanning the horizon with idle interest, or perhaps puzzling at the diverse life populating this strange planet.[14] Where the first section suggests organismic correspondences by combining time-lapse imagery with voice-over commentary, here the city-as-organism is developed through strictly visual juxtapositions. To this end, Harris makes dramatic use of scientifically-sourced microphotography—of blood cells,

[13] Hollister's score is a marked contrast to Philip Glass's music for *Koyaanisqatsi*—atonal and uninterested in the latter's infectious chord progressions and their logic of mounting emotional momentum. On the importance of Glass's *Koyaanisqatsi* score, see Mitchell Morris, "Sight, Sound, and the Temporality of Myth Making in *Koyaanisqatsi*," in *Beyond the Soundtrack: Representing Music in Cinema*, ed. Daniel Goldmark, Lawrence Kramer, and Richard D. Leppert (Berkeley: University of California Press, 2007), 120-35.

[14] Gary Matthew Varner attributes a similar sort of gaze—specifically, an impassive, posthuman "mechanical stare"—to *Koyaanisqatsi*'s time-lapse cinematography. Gary Matthew Varner, "*Koyaanisqatsi* and the Posthuman Aesthetics of a Mechanical Stare," *Film Criticism* 41, no. 1 (2017), np. DOI: http://dx.doi.org/10.3998/fc.13761232.0041.104.

neural networks, microbial infections—integrating this imagery seamlessly with his urban footage.[15] His techniques for joining the body and the city are similarly creative, involving dissolves between shots with similar color palettes, hard cuts between graphically congruent images, and transitions where the dissolve from medical to urban is disguised by fuzzy focus, which is then gradually sharpened.

The last section of the film blends together the elements and tonal features of the first two sections—lectures and electronic music, medical footage and urban time-lapse imagery—giving them mounting urgency and momentum. This section is also where Harris's time-lapse experiments become most virtuosic and grandiose. Not only do we see images describing the discrete systems and processes that unfold within the city, but we see particularly impressive shots that frame a panoramic view of the cityscape abiding beneath tumultuous skies, passing between day and night in brief punctuated gasps. The angle of view is, on the one hand, highly familiar: we have seen this photogenic city depicted from this same vantage who knows how many times before. But Harris exploits and reworks the iconic familiarity of Manhattan's skyline—makes its generic familiarity a basis for exploring the possibilities of time-lapse techniques themselves, as if testing how these temporal compressions frame time in ways akin to the camera's wide-angle grasp of space. Rather than dissect the city into its constituent subsystems, these technical gestures picture the city as a vital and integrated whole. Twice we are invited to gape at the extending sweep of the city's nocturnal ecology, as indexed by complementary patterns of artificial light—the

[15] The inclusion of this scientific footage could, of course, be productively read through a Barthesian semiology. Whereas in the pasta advertisement Barthes analyzes, various items are included as bare markers of "Italianicity," here the medical footage (whose subjects, other than blood cells, are generally impossible for a nonspecialist to identify) signifies nothing more specific than "Biology," or perhaps (guided as we are by the film's title and the audio samples from medical lectures) as "Organism-ness." Barthes, "The Rhetoric of the Image," *Image-Music-Text*, trans. Stephen Heath (New York: Hill and Wang, 1977), 32-51.

electrified grids of office towers bounded by streetlights and streaking headlights, the swooping beams of aircraft taking off and landing, apartment windows lighting up and turning off like a titanic switchboard. Another memorable shot inhabits these diurnal cycles by tracking the shadow of the Empire State Building as it sweeps clockwise over the face of Manhattan below—the skyscraper repurposed as a sublime sundial.

We can begin to see how time-lapse photography figures in the film's analytic and synthetic gestures—how Harris parses the city into a set of rational functions, and how he evokes the larger, coherent whole to which these functions contribute. Time-lapse techniques are part of the film's rhetorical toolkit, enabling the juxtapositions, analogies, and comparisons that promote the organismic argument, a "particularly useful means for revealing the systematic structures of modern urban life."[16] The message—that the city is like, or *is*, a sort of organism—is bluntly laid out in the early "anatomy lesson" section, where New York's industries, infrastructures, and professional classes are framed as counterparts to specific physiological systems. This thesis is then elaborated and emotionally reinforced through the juxtapositions of microcinematography and traffic footage, in which macroscopic and microscopic systems are shown to overlap graphically and correspond rhythmically. The majestic panoramas of the island enduring the day's passage into night, its dusky interior sparkling with innumerable points of light, also contribute to this impression of the city as a self-enclosed, internally variegated, self-sustaining whole.

Besides enabling these comparisons, Harris's heavy reliance on time-lapse camera techniques has other ideological implications that may or may not have been intended.

[16] MacDonald, *The Garden in the Machine*, 167.

Especially in *Organism*'s first section, much of our focus is on the movements of anonymous *machines*—cranes and trucks, trains and conveyer belts—and not the laboring bodies of stevedores, garbage collectors, delivery men, and construction workers.[17] Time-lapse seems to encourage this fixation on automatism, rendering the human workers (and diners and commuters) as extensions or analogs of mechanical operations. The individuality of human beings is blurred into indistinction, their labors lost between successive exposures. When Harris time-lapses a construction site, for example, it is almost as if the *scaffolding* were the agent that dismantles and repairs the building. Framed by the film's thematic concern for the "organism," these expressions of automatism are in more than one sense naturalized, throwing a mist over the realities of labor, design, and decision that determine the built environment. Representing infrastructures and institutions in this way—as spontaneous projections of natural, evolved, vital systems, and not as the fruit of deliberate choice and political interests—posits industrial capitalism as inevitable, foreclosing any alternative model of social organization. Paradoxically, all this swarming movement adds up to a static conception of social reality. This effect is especially telling in a sequence in which the lecturing voice-over describes the brain's modes of storage and access. As illustrations, we see footage of phonebook pages, birds eye shots of the urban grid, streams of punch cards, and the automated sifting and sorting of envelopes. "The vast majority of the brain's activity," the disembodied voice blandly informs us, "is automatic and involuntary."

[17] Varner ("*Koyaanisqatsi* and the Posthuman") remarks a similar tendency in Reggio's film, interpreting its time-lapsed shots of workers entering and leaving factories as a critique of the militarized, mechanized logic of modern capitalism. From this perspective, it is not that the time-lapse technique erases human labor, but that its mechanical gaze perceives a peculiarly modern *reality* to which habit otherwise blinds us: that the "human" has been largely eliminated from collective forms and synchronized logics of industrial labor.

If Harris's time-lapse portraits tend to reduce the human variables of labor, design, and agency from the urban equation, they similarly tend to outsource authorial responsibility for the film's rhetorical machinations. The organismic conclusion is, it seems, supposed to flow *automatically* from the guided accumulation of images, without any substantive evidence or argumentation. To put a finer point on this, the film's rhetoric glosses over the distinction between *form* and *function*—a distinction as critical to the life sciences as it is to architecture and urban planning.[18] The film's imagery often solicits our wonder at the *formal* analogies it has orchestrated, and it uses time-lapse photography to amplify these graphic analogies by showing how they also correspond temporally, producing the same rhythms in their pulses of movement and stasis. But where, in biology, noting formal similarity is an entrée to deeper comparative analysis, a search for *homologies*, *Organism* tends to move brusquely to the conclusion that these phenomena correspond in their *functions*, too. This sense of form implying function is strongest in the middle section, which repeatedly compares urban and arterial structures. At first, these correspondences are promoted through graphic matches, highlighting how urban and bodily *structures* resemble one another. But with time-lapse photography's modulation of the rates of phenomenal movement, these likenesses of shape and linear pattern are extended into harmonies of *movement*: temporal patterns of body and city are shown to transpire in neat synchrony.

In short, time-lapse photography lends itself to the city-as-organism thesis, complementing and enhancing the array of formal and rhetorical devices Harris employs. This camera technique, combined with conventions of montage, helps deepen the sense of

[18] In biology, the classic work on form and function (and their conflation) is E.S. Russell, *Form and Function: A Contribution to the History of Animal Morphology* (London: John Murray, 1916).

kinematic correspondence between the city and the organism, and it is up to us to decide how persuasive we find these purely visual alliances, and whether they imply deeper, functional similarities. Godfrey Reggio has characterized his adoption of time-lapse photography in *Koyaanisqatsi* in ways that similarly conceive it as a rhetorical tool, a "visual language" he could invoke to articulate the spirit of societal acceleration.[19] In the case of Harris's film, however, this instrumental account of time-lapse imagery fails to do justice to its aesthetic impact. In particular, it misses the significance of how Harris *experiments* with time-lapse techniques, exploring the technique's specific "possibilities." I would like to change course, then, and think about how his tinkering with the camera fed directly into deeper formal discoveries and helped raise questions about vital self-organization. To frame this experimental impulse, the next two sections focus on the two genealogical sources of time-lapse imaging that *Organism* seems to acknowledge: the hybrid genre of "city symphonies," and the forms of technical experiment on which these films are predicated; and the development of time-lapse techniques in the institutional context of early-1900s biology, especially in relation to paradigm disputes regarding the primacy of the organism versus the cell.

Technique, Form, and the City Symphony

With roots in the urban actualities of the Lumières, the "city symphony" is a nonnarrative genre straddling documentary and the avant-garde, marked by its concern with

[19] MacDonald, "Interview with Godfrey Reggio."

poetically rendering the typical features and experiences of a given city.[20] City symphonies inevitably oscillate between the general and the particular—the total or composite description of the city, its iconic sites and monuments, its characteristic infrastructures, its governing mood, a "cross-section of life in the modern metropolis."[21] But they are also attuned to the internal diversity of the city's inhabitants, its idiosyncratic enclaves, its local customs, its street-level grit and aromas, embracing the figure of diurnal cycles—a "day in the life" of the city—to give these details coherent form.[22] With expressions of daily urban life as its core material, *music*, of course, is the key structural and artistic reference point for the "city symphony," an alliance that suggests that the city's harmonizing of part with whole resembles the "unified and coherent performance within which the individualities of contributing musicians are subsumed."[23] Granting that these "creative geographies" are in some sense symphonic, the work of the filmmaker is a labor of *composition* (or perhaps orchestration), gathering diverse views of the city and organizing these into a coherent, flowing experience—an experience which may in fact be set to a musical score whose rhythms and progressions the film reproduces visually, or one whose visual rhythms and shapes evoke musicality in themselves. In this oscillation of document and experience,

[20] On the relevance of the Lumières, see Paul Arthur, *A Line of Sight: American Avant-garde Film Since 1965* (Minneapolis, MN: University of Minnesota Press, 2005), 45. On the city symphony's challenge to "the categories of avant-garde and nonfiction film as they were discussed in the 1920s and 1930s," see William Uricchio, "The City Viewed: The films of Leyda, Browning, and Weinberg," in *Lovers of Cinema: The First American Film Avant-Garde: 1919-1945*, ed. Jan-Christopher Horak (Madison, WI: University of Wisconsin Press, 1995), 287.
[21] Edward Dimendberg, *Film Noir and the Spaces of Modernity* (Cambridge, MA: Harvard University Press, 2004), 109. The metaphor of the city film producing a "cross section" is repeated by a number of critics, including Siegfried Kracauer, *From Caligari to Hitler: A Psychological History of the German Film* (Princeton, NJ: Princeton University Press, 1966 [1947]), 181.
[22] Keith Beattie, "From City Symphony to Global City Film: Documentary Display and the Corporeal," *Screening the Past* 20 (2006), 2.
[23] MacDonald, *The Garden in the Machine*, 152.

montage commands the greater share of our aesthetic attention: the art of the city symphonist seems, by and large, to be an art of editing.[24]

Critical writings on city symphonies have often been proxy battles over notions of realism and formalism, staged upon the premise that these films "[privilege] editing as a means of instating urban rhythms."[25] Charges of empty formalism against city films go hand in hand with the notion that the "rhythms, parallels, and contrasts" they posit are superficial, and not substantive.[26] Walter Ruttmann's *Berlin: Symphony of a Great City* (1927) has long been the paradigmatic example of the city symphony as a cinematic form, and the "epicenter" (as Keith Beattie puts it) of criticism aimed more broadly at the formalism and politics of city films in its mold.[27] Critics like John Grierson and Seymour Chapman have complained of *Berlin*'s superficiality, its "excessive formalism," its "unmotivated camera mischief," its reduction of the city to "rhythm, and nothing else."[28] The classic instance of this critique, though, is Siegfried Kracauer's analysis of the film in his chapter, "Montage," in *From Caligari to Hitler*.[29] There, Kracauer excoriates Ruttmann for his purely "surface approach," which is continually satisfied with compiling a series of "striking analogies," but which fails to perceive or imagine the social mechanisms beneath these surface expressions (184). According to this critique, Ruttman is an aesthete, devoted to art at the expense of politics, attuned to "the formal qualities of objects rather than . . . their meanings" (184). A

[24] Dimendberg, *Film Noir and the Spaces of Modernity*, 109; Arthur *A Line of Sight*, 46.
[25] Arthur, *A Line of Sight*, 46.
[26] Beattie, "From City Symphony to Global City Film," 2; Dimendberg, *Film Noir and the Spaces of Modernity*, 109.
[27] Beattie, "From City Symphony to Global City Film," 2.
[28] These critics are cited in Beattie. The charge of "unmotivated camera mischief" is Sergei Eisenstein's. See also Seymour Chapman, "Two Aspects of the City: Ruttmann and Cavalcanti," in *The Documentary Tradition*, ed. Lewis Jacobs (New York: Norton, 1971), 37-42.
[29] Kracauer, *From Caligari to Hitler*, 181-188. Hereafter cited in-text.

telling example of this general tendency, for Kracuaer, is a scene of wage workers funneling out of a building, which is immediately juxtaposed with aristocrats gathered at an extravagant soiree. Where another filmmaker might have painted such a tonal contrast in order to induce a deeper analysis of the material sources of economic disparity (recall, for instance, a similar contrast in Griffith's *A Corner in Wheat* [1910], between a breadline and a dinner party), Ruttmann settles for the pleasing rhythmic punctuation these images establish (185). Kracauer repeatedly tropes this political obtuseness as a failure to "penetrate" the reality *Berlin* renders—a failure to show the social significance of things, cataloguing "thousands of details without connecting them," presenting "facts" without "meaning," in short: "showing much and revealing nothing" (185, 187, 188).[30]

It is important to note how this line of criticism lodges the film's artistic validity—its depth or superficiality, its capacity to draw meaningful connections or probe political conditions—in the power of editing. This singular emphasis on the effects and implications of montage similarly entails the notion that aesthetics are separable from a film's purported message or theme, that its formal features can either strengthen or stand at odds with its discursive argument. A critical emphasis on the use and abuse of montage, in other words, ingrains the notion that camerawork is merely preparatory to the truly creative gestures of selecting, trimming, and arranging footage—a notion rehearsed more recently in Vilém Flusser's account of the "gesture of filming."[31] But it is well to remember that the affinity between cinema and the city can be even more basic than these attempts, at the editing table, to reproduce or translate urban experience into visual music. The earliest city films attest to

[30] Kracauer's celebrated counterexample to *Berlin* is Dziga Vertov's *Man with a Movie Camera* (1927)—a film that offers a genuinely "penetrating" vision of the (soviet) city.
[31] Vilém Flusser, "The Gesture of Filming," *Gestures*, trans. Nancy Ann Roth (Minneapolis, MN: University of Minnesota Press, 2014), 86-90.

an exploratory impulse, a desire, perhaps raw and inarticulate at first, to document the urban milieu—the milieu which, for the Lumières and for Edison alike, was simply *there* beyond the confines of the studio.[32] For early film pioneers, the city was an appealing, readily available laboratory in which to test the capacities of motion picture equipment, an environment full of dynamic phenomena and modern structures that could be captured by, and compared with, the cinematograph. As William Uricchio puts it, "city films simultaneously addressed the urban realities before the camera and the film medium itself,"—they explored the city at the same time that they tested motion-picture equipment. This entanglement of exploration and experiment persisted as urban actualities gave way to poetic documentary studies of the city and ornate, grandly scaled city symphonies.[33] The dual urge to explore terrain and technology is what I want to characterize as the city film's *experimental impulse*. If we take seriously this dialectical drive to document the city—the instinctive compulsion to tinker and experiment with camera equipment in the course of the filmmaker's urban excursions, continually adapting and responding to the peculiarities of this environment—then qualities of the footage itself, of camera technique and technology (and not only effects of montage), warrant more critical consideration.

One way to conceptualize this rapport between camera experiment and urban form is through Brian R. Jacobson's notion of "infrastructural affinity."[34] Jacobson illustrates this notion through several early New York actualities, each of which showcases a different experiment with camera technique in confronting changes underway in that rapidly modernizing city. One of these is the Edison short, *Building up and Demolishing the Star*

[32] MacDonald, *The Garden in the Machine*, 149.
[33] Uricchio, "The City Viewed," 292.
[34] Brian R. Jacobson, "Infrastructural Affinity: Film Technology and the Built Environment in New York circa 1900," *Framework: The Journal of Cinema and Media* 57, no. 1 (2016): 7-31.

Theatre (Frederick S. Armitage, 1901). Shot over a month in 1901, taking a single frame every four minutes during each working day, the film documents the dismantling of New York's Star Theatre.[35] As this slow, systematic enterprise is run through the film projector, it becomes (like other time-lapse effects) an astonishing vision of urban space rapidly transforming: the building dissolves before our eyes, beginning with the top story and continuing downward, as if devoured by cartoon termites. In fact, we can see that the intricate labor of destruction is accomplished by faintly visible workers who swarm over the structure as the shadows of nearby skyscrapers sweep over the scene in clockwork cycles. As the film's title indicates, however, the show is not over once the building has been digested down to its foundation. *Star Theatre* was originally distributed with instructions to the projectionist, suggesting that once the reel was completed it should be run once more, backwards, so that the building defies its demise and wills itself back into existence, rising up from its foundations and materializing once again.[36] The clock runs both ways in this new technological regime, the film seems to say, dramatizing the malleability of cinematic time with and through the city's rapidly transfigured environments.[37]

Jacobson's notion of "infrastructural affinity" links urban transformation and emergent cinematic technology. It describes a sort of mutual attraction and compatibility between motion pictures and the urban environment, a "correlation" of film technology with the increasingly technological forms and logics of the modern, dynamic metropolis. Jacobson characterizes this relationship as thoroughly mutual, a "dual affinity" in that film

[35] Jacobson, "Infrastructural Affinity," 11.
[36] Jacobson, "Infrastructural Affinity," 10.
[37] Attention to how the emergence of cinematic technology coincided with changes in the experience of temporality is thematic in much writing on cinema and modernity, notably in Mary Ann Doane's *The Emergence of Cinematic Time: Modernity, Contingency, the Archive* (Cambridge, MA: Harvard University Press, 2002).

was apt to "record, reveal, and enhance the city's architectural development."[38] Film and architectural experience seemed to acknowledge and amplify one another, so that buildings and infrastructures became "extensions of the filmic apparatus, [creating] cinematic views that mimicked and attempted to enhance the kinds of visual experiences made possible by the buildings themselves."[39] Jacobson focuses on several of early cinema's own infrastructural developments, specifically "rotating tripod heads, devices for time-lapse photography, in-camera editing techniques, and artificial lighting effects," and argues that these technical innovations were applied to the city's swiftly changing infrastructures in ways that acknowledged an intrinsic similarity between subject and medium.[40] Within this dialogic relationship, film technique and the built environment both resembled and experientially complemented one another. Manhattan's ongoing "creative destruction" was both photogenic (or rather, cinegenic), calling out for capture by *moving* images, but also material in relation to which filmmakers could tease out their instruments' affordances and capacities.[41]

Film historians have long noted the symbiotic, mutually illuminating rapport between cinema and the twentieth-century city, especially stressing how both film and the city were integral to the visual culture of modernity—the ubiquitous jolts and shocks that qualified one's experience of the boisterous city and of early cinema's barking, sensational address.[42]

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[38] Jacobson, "Infrastructural Affinity," 16.
[39] Jacobson, "Infrastructural Affinity," 16.
[40] Jacobson, "Infrastructural Affinity," 8.
[41] The "creative destruction" of Manhattan is an expression Jacobson borrows from historian Max Page. "Infrastructural Affinity," 8.
[42] See the contributions to the collection *Cinema and the Invention of Modern Life*, ed. Leo Charney and Vanessa R. Schwartz (Berkeley, CA: University of California Press, 1995); and Ben Singer, *Melodrama and Modernity: Early Sensational Cinema and its Contexts* (New York: Columbia University Press, 2001). Also relevant is Scott Bukatman's notion of "kaleidoscopic perception" in *Matters of Gravity: Special Effects and Supermen in the 20th Century* (Durham, NC: Duke University Press, 2003).

Jacobson's readings of New York actualities add another layer of experience to this account: not just the phenomenology of the crowd and the culture of urban film-going, but the experimental itineraries of the film technicians themselves. Films like *Star Theatre* exemplify how the camera's tweakable elements intuitively corresponded to the temporal and scalar dimensions of the city's experiential matrix. In particular, *Star Theatre* modulated and reconfigured time in order to capture (and spectacularly reprocess) the city's implacable momentum, its iterative structure, and its often cyclical logic—"building up" and "demolishing" only to "build up" again. Time-lapse techniques could accommodate collective labor's diurnal cycles, translating into cinematic terms the eight-hour spans and incremental progress of the construction crew's working day. This laborious routine neatly corresponds to a principle of film production—the mechanical clockwork of sequentially exposed frames—and delivers a spectacular payoff once we get to see the destruction of the theatre as a cumulative, continuously unfolding accomplishment. Jacobson notes a similar attunement of profilmic phenomenon and filmic apparatus, in that "the daily ritual of regulating light and heat becomes both a cinematic spectacle and an analog for the rhythmic movement of the aperture that defines film's own regulations of light."[43]

Jacobson's discussion of early cinema's infrastructural affinities draws attention to innovative experiments with camera equipment, and the complex significance of these experiments in relation to the rapidly changing urban environment. Devices like time-lapse photography were part of the technical means through which filmmakers encountered and interpreted this environment, and through which they articulated a series of formal homologies between the cinematic medium and the city's built forms. I would like to build

[43] Jacobson, "Infrastructural Affinity," 13.

on this acknowledgment of the film camera's tweakable components (as opposed to, or at least preparatory to, the creative intervention of editing), considering how time-lapse's in-camera modification of framerate was occasionally rediscovered by later filmmakers who integrated an experimental impulse with their explorations of the city—especially, it turns out, explorations of New York.

The working out of this experimental impulse was in an important sense linked to a romantic embrace of amateurism. The amateur, in the value system of the experimental "New American Cinema," was a figure animated purely by love for, or fascination with, the film medium—a figure removed from the institutional logics of Hollywood, someone whose lack of training primed them for new discoveries.[44] Unguided in the use of equipment and, so far as possible, "untutored" in habits of sight, the amateur was someone willing to "try out," for affection's sake, the range of contexts and uses to which one's small-gauge camera might be put.[45] As such, this amateur ethic placed a premium on the event of filming, making editing a secondary concern, or even embracing a home-movie aesthetic in which all "cuts" were made in-camera.[46] Among avant-gardists, this embrace involved a handful of related gestures—including Jonas Mekas's home-movie-styled compilation films, like *Walden: Diaries, Notes and Sketches* (1968) and *Reminiscences of a Journey to Lithuania* (1972); the Duchampian repurposing of "found" or "mere footage," as in Ken Jacobs's

[44] On the valuation of amateurism among experimental filmmakers, see Maya Deren, "Amateur versus Professional," *Essential Deren: Collected Writings on Film by Maya Deren*, ed. Bruce R. McPherson (New York: Documentext, 2005), 17; David E. James, "Amateurs in the Industry Town: Stan Brakhage and Andy Warhol in Los Angeles," in *Stan Brakhage: Filmmaker*, ed. David E. James (Philadelphia: Temple University Press, 2005).
[45] The emphasis on "untutored" vision is famously laid out in Stan Brakhage, "Metaphors on Vision," *Essential Brakhage: Selected Writings on Filmmaking*, ed. Bruce R. McPherson (New York: Documentext, 2001), 12.
[46] Jonas Mekas, "8 mm. Cinema as Folk Art," *Movie Journal: The Rise of the New American Cinema, 1959-1971* (New York: The Macmillan Company, 1972), 83.

Perfect Film (1986);[47] and the tentative subgenre of the "film diary," as exemplified in the always-in-process, ever-accumulating, rarely-formally-finished work of Marie Menken.[48] In all these cases, the event of filming, the unscripted encounter between camera and environment, embodies what is "experimental" about experimental film—much in the affinity-testing spirit of early filmmakers documenting the modernizing metropolis.

One film that thrives on this sort of amateurish zeal, preserving the beginner's zealous tinkering with new equipment, is *Weegee's New York* (1948). Weegee (the professional pseudonym of Arthur Felig) was not a typical amateur: he was an established photographer by profession, renowned for his harsh, flash-lit portraits (emblematized in his well-known 1945 collection *Naked City*) of New York's seedier neighborhoods, its economies of vice, its disavowed underclasses and institutions.[49] Without, it seems, any preconceived plans for his footage, Weegee began experimenting with consumer film equipment in the 1940s, shooting casually around the city as an extension of his perambulatory regimen. This casually compiled test footage was edited into a standalone film only subsequently, almost as an afterthought, in collaboration with Amos Vogel, founder and curator of Cinema 16 from 1947 to 1963.[50] Vogel, it seems, was struck by the power of Weegee's intuitive, unassuming film work, and took the lead in trimming and organizing this footage into *Weegee's New York*. Much of the quiet originality of Weegee's film lies, as Scott MacDonald notes, in the

[47] According to Jacobs, the footage in *Perfect Film* is simply the unedited, discarded camera roll from a TV news reporter (covering the aftermath of Malcolm X's assassination in 1965) that Jacobs recovered from a dumpster, and then released, unaltered, as a literal "found footage film."
[48] On the notion of the "diary film," and Menken's and Mekas's privileged relation to it, see P. Adams Sitney, *Eyes Upside Down: Visionary Filmmakers and the Heritage of Emerson* (New York: Oxford University Press, 2008), 21-47, 83-97.
[49] For a discussion of Weegee's *Naked City* in connection with the aesthetics and geographies of urban film noir, see Dimendberg, *Film Noir and the Spaces of Modernity*.
[50] MacDonald, *The Garden in the Machine*, 161.

photographer's easy familiarity with ordinary citizens enjoying their moments of leisure. A diverse community of strangers acknowledge and jubilantly interact with Weegee's camera as though this were a home movie of friends and familiars;[51] and while his gaze tends to linger leeringly at the seminude bodies around Coney Island, it also welcomes the return of that gaze in jocular confrontations, gesturing toward the utopian reciprocity of "a society that comes to life precisely when it is not being 'productive'."[52]

If these earthy filmic excursions extend Weegee's sensibility as a still photographer, his time-lapse experiments open his technical amateurism to other lines of possibility. In *Weegee's New York*, these time-lapse tests are grouped into a stand-alone "dream" section whose iconography (though not its joyous tone) contrasts with the intimate scale at which street-life and beach-life are portrayed. The "dream" section's sequence of time-lapse shots frame Manhattan from across the East River: the metropolis abides beneath tumultuous skies, encircled by ferries and tankers that skate across the river in nervous commutes. Taking these brief dusk-to-dawn profiles of the cityscape together with the rest of the film's ground-level encounters with energetic bodies and smiling faces, the film tentatively integrates radically differently-scaled perspectives on the life of this island-bound metropolis. One might also say that the film straddles two different approaches to collective portraiture—on the one side, the faces of the diverse individuals who, thanks both to montage and to several striking mass portraits, gradually meld and coalesce into a collective body (*e pluribus unum*);

[51] This embrace (or avoidance) of the returned gaze in city films is a central concern of Beattie, "From City Symphony to Global City Film."
[52] MacDonald, *The Garden in the Machine*, 163.

on the other, the physiognomy of the city as a whole, pictured (thanks to time-lapse photography) as a single, dynamic, coherent entity.[53]

A similar fusion of amateur zeal and experimental vigor is on display Marie Menken's *Go! Go! Go!* (1962-64), a film whose time-condensing portrayal of New York anticipates Harris's *Organism*. Time-lapse photography, in these mid-century city symphonies, recurs as a figure of experimental tinkering in relation to the urban environment. The use of time-lapse in *Go! Go! Go!* is exceptional, though, in at least two ways: first, the manipulation of frame-rate persists throughout the film's fifteen-minute running time; second, this persistent technical tinkering departs from conventional, professional time-lapse imagery in ways that betoken formal and thematic insights. Whereas time-lapse acceleration typically involves a tripod to steady the camera and a timing mechanism to regulate exposures, thereby ensuring that the phenomenon pictured moves smoothly within a stationary frame, Menken produced her effect by hoisting her Bolex camera in her arms and, at roughly regular intervals, manually ticking off one frame at a time—a technique known as pixilation.[54] The unorthodox laboriousness of Menken's filming methods results in a wildly unsteady image: the jitters and jumps of the handheld camera are intensified by the irregular frame rate, whether the filmmaker is careening down Manhattan sidewalks, panning her gaze to follow the movements of afternoon ferries, or simply observing the effluence of businessmen out of a downtown office building. The time-lapse effect amplifies even the

[53] Béla Balázs's concept of physiognomy was famously rooted in the form of perception activated by close-ups, but he also entertained the notion that extreme long shots could animate the physiognomy of a landscape or a crowd of people: "These masses have a *physiognomy* of their own, which is as expressive as only a face can be: a mass physiognomy." *Béla Balázs: Early Film Theory; Visible Man and The Spirit of Film,* ed. and trans. Erica Carter and Rodney Livingstone (New York: Berghahn Books, 2010), 145.

[54] Paul Arthur discusses this technique in *Go! Go! Go!* and in *Surface Tension* (Hollis Frampton, 1968), in *A Line of Sight*, 52. MacDonald further describes the effect of Menken's pixilation as "causing single-frame images of different people and places to pile up into 'retinal collages'," *The Garden in the Machine*, 166.

subtlest deviations in the camera operator's posture and carriage, all those telltale somatic tics that Hollywood's professional codes took pains to smooth away. Menken's technical choices foreground rather than disguise the faltering imperfections of her mobile body.[55] She similarly bucks the usual protocols of time-lapse imaging in her choice of subject matter. Rather than telescope time to compensate for the gradualness of building construction or the diurnal movements of shadows, *Go! Go! Go!* mostly navigates the city from within, at ground level, continually inspecting the quotidian doings of ordinary New Yorkers. Rather than segregate wide temporal frames and spatial close-ups, as *Weegee's New York* does, *Go! Go! Go!* combines them in-camera in depicting social process—often to humorous effect.

Like her other film work, Menken's *Go! Go! Go!* was the fruit of her diaristic approach to filmmaking—her need just *to film* without much foreplanning, to film her experiences as a dimension of living her life, adding celluloid pages to a film diary whose finished form or audience she made no show of expecting. Her time-lapse experiments come out of, and remain true to, that intuitive, impulsive need to couple technical experiment and personal experience. In the process, she rediscovers one of time-lapse's most primitive virtues: not its rhetorical utility in advancing a pre-formed thesis, but its power as an instrument of fortuitous *discovery*. What she discovers (and complicates, and comments upon) in her meanderings, pertains to one of the city symphony's generic preoccupations: city life's tendency to self-organize into collective rhythms and patterns. Yet she comes to these discoveries in a way that differs from the stylistic protocols of her high modernist forebears, including their occasional, refined time-lapsing of urban process. By combining

[55] On American experimental film culture's antipathy to Hollywood professionalism and embrace of hanheld camera techniques, see Sitney discussion of "somatic camera" in *Eyes Upside Down*, 21-47.

time-lapse pixilation, handheld camerawork, and ground-level perspectives, for example, Menken gives her subjects a frenzied energy and comic sensibility, thereby "critiquing the very seriousness of the tradition she inherited."[56] Where earlier time-lapse records like *Star Theatre* had made construction projects evolve with the elegance and inevitability of natural growth cycles, Menken's head-long, rushing gaze seems to render the city more and more bewildering and incomprehensible. Earlier films in this tradition had evoked and exaggerated the city's accelerating pace, complexity, and confusion. But where these films produced these effects through carefully measured editing patterns, communicating either a concerned or celebratory perspective, Menken uses her idiosyncratic camerawork to cast a wry, irreverent eye at the seriousness with which we all participate in modernity's systematic confusions—as she put it, "the busy man's engagement in his busyness."[57]

In keeping with the visionary ethic of her avant-garde cohort, Menken uses cinematic technique to *defamiliarize* our most invariant routines, those rituals we perform with a dutiful lack of reflection.[58] Her camera observes, with egalitarian skepticism, disparate strata of social performance: the swarming ingress and egress of company men from downtown office buildings; the streamlined march of capped-and-gowned college graduates rising to accept diplomas; a pageant of body builders strutting and posing and bowing to a jubilant crowd; a writer (Menken's husband, the poet Willard Maas) on a balcony sitting, rising, pacing, sitting again, in antsy agitation. In each case, the jittery frame and the frenzied on-screen action make us see these behaviors in a new light. The specific contours of each behavior are

[56] MacDonald, *The Garden in the Machine*, 167.
[57] Quoted in MacDonald, *The Garden in the Machine*, 166.
[58] On defamiliarization as an aesthetic paradigm, see Victor Shklovsky, "Art and Technique" in *Russian Formalist Criticism: Four Essays*, ed. and trans Lee T. Lemon and Marion J. Reis (Lincoln, NE: University of Nebraska Press, 1965).

redrawn as forms of mechanical repetition, their real-time grace converted to fidgety nervousness, individual distinctions subsumed by the force of collective flow. We lose any sense for the cultural meaning and private significance of these diverse rites and ceremonies. Instead, unflatteringly, we see how these collective movements, whether mundane or momentous, recall the turning of clockwork gears or the cycling of commodities along a conveyer belt. The shift in time-scale amounts to a change in optic: we lose the fine grain of individual experience (the sense of intellectual or physical accomplishment that must swell in the consciousness of college graduates and body builders, alike, as they ascend their respective podiums), but see more clearly the abiding logic that binds individuals to social conventions, the visible but unchosen and unperceived patterns that these conventions describe. This insight is wrapped up in the capacity to perceive the patterns and rhythms into which these time-lapsed behaviors coalesce: in perceiving the pattern, we can perceive and judge the conventionality itself. The emotional power of this critical revelation is distinct from those rendered by means of montage—we experience these phenomenal rhythms as optical *discoveries* due to the revelatory magic of the camera, not as slick illustrations of known principles.

This last observation recalls Kracauer's famous complaint with *Berlin*—that Ruttmann's predilection for formal pattern blinded him to deeper material realities, emphasizing "formal qualities of objects," "striking analogies," and "pure patterns of movement," but failing to penetrate to the real "meanings" and "functions" of these dynamic phenomena.[59] Kracauer's criticism takes for granted that a film's aesthetic surface can be uncoupled from its deeper thematic content, so that pictorial abstraction repels indexical

[59] Kracauer, *From Caligari to Hitler*, 184-5.

realism, and the form in which we perceive something can be made to bely (or ignore) that thing's real function. In assessing Menken's intuitive camera experiments in *Go! Go! Go!*, however, these binary frictions seem to break down, especially where the formal analogies evoked by her time-lapse excursions involve simultaneously adjusting our perception of social reality. Juxtaposing Menken and Kracauer in this way reminds us of the complex, overriding phenomenon that city symphonies are supposed, with varying success, to record and depict: namely, the notion of "life" specific to the modern city. Kracauer speaks of *Berlin* and *Man with a Movie Camera* as attempts to illustrate the generic character of urban life, to say "such is life," or to sketch a "cross-section" of a city's varied forms of living. Vertov famously described his cinematic vocation as catching "life unawares," and pursued this observational ideal through an (ethically dubious) use of concealed cameras.[60] Later critics like Arthur and MacDonald have identified the city symphony's penchant for organizing its footage as a "day in the life" of a given metropolis, or else inspecting one of its boroughs as a synecdoche of the greater urban ecology.[61] These and other colloquial metaphors identify "life," however vague or amorphous that concept might be, as the object and/or structural model of these city films. But what sort of phenomenon is "life" supposed to be, according to these films? "Life" here is abstracted from individual human agents, and its rendering sidesteps the usual formal mechanism (clearly defined characters, a sequence of causal events) by which a movie narrates *a* life. Instead, "life" in these films is lodged in a different sort of thing, or quality—the city itself, perhaps, or a collective body that exceeds the sum of its citizens—and portrays this subject through a specialized, often experimental

[60] Annette Michelson, ed., *Kino-Eye: The Writings of Dziga Vertov*, trans. Kevin O'Brien (Berkeley, CA: University of California Press, 1984).
[61] MacDonald, *The Garden in the Machine*, 151; Arthur, *A Line of Sight*, 50.

vocabulary. It is all the more fitting that experimental filmmakers would grapple with time-lapse photography as a way to render and reveal "life." As we will see in the next section, camera experiments (like time-lapse) were significant in the life sciences, not just helping to illustrate or vivify the qualities of vital phenomena, but participating directly in defining what life *is*.

Time-lapse Photography and Cinematic Organisms

I earlier observed that, unlike classic iterations of the city *symphony*, *Organism* does not seem to invoke music as its definitive formal and experiential analog. Instead, as its title suggests, the film insinuates the biological concept of the *organism* as a structuring metaphor. At this point, it is worth asking what the concept of the organism entails: how is it biologically defined, and how can this definition be brought to bear on aspects of film style and camera technique? How did *Harris* understand the notion of the organism? Is it scientifically valid or intellectually legitimate to compare organismic structures to the built forms and engineered systems of the modern city, as Harris does? And what role can a visual medium like cinema (or, more narrowly, the device of time-lapse photography) play in articulating the organism's essential features, or in guiding comparisons between biological and social phenomena as such?

In interviews, Harris acknowledged that he was deeply impressed by the "New Age thinking" that he saw emerging during the period (the 1960s and early 1970s) of *Organism*'s gestation.[62] He characterizes this epistemology as "a new consciousness that's coming into

[62] Harris, 1973 interview with Robert Gardner, *Screening Room.*

the world," partly prompted by globalization and ecological crisis, which involves a greater appreciation for the interdependencies of diverse societies, a need to move beyond patterns of domination and exploitation, and the "need to experience the environment in a new way."[63] These comments give important authorial context to *Organism*, but by alluding to "New Age thinking," "environmental interconnection," and "networked interactions," Harris also evokes a larger pattern of paradigm shifts then underway in economics, politics, and across the sciences. The significance of systematic interconnections had been emphasized in a series of paradigm-breaking papers: for example, in the formulation of "chaos theory"; the dissemination and application of cybernetics; Lovelock's "Gaia hypothesis"; sociological critiques of globalization; and the coinage of "autopoiesis" (the powers of self-organization exhibited by living beings)—to cite only a few.[64] One touchstone of the rapid absorption of these ideas into the public sphere was Lewis Thomas's best-selling collection of science essays, *The Lives of a Cell*—a book that meditates on the patterns that echo across disparate scales of being, from the cell, to the organism, to the social collective, to the Earth system imagined as a living, breathing whole.[65] As specific as this flowering of systems-oriented paradigms was to the mid-century zeitgeist, it had roots in the first years of the twentieth century. Prigogine, in particular, acknowledged how his formulation of complex systems in physics and chemistry coincided with rediscovering the work of forebears like Henri Poincaré, Claude Bénard, and Stéphane Leduc, all of whom studied phenomena at the

[63] Harris, 1979 interview with Robert Gardner, *Screening Room*.
[64] Fritjof Capra, *The Web of Life: A New Scientific Understanding of Living Systems* (New York: Anchor Books, 1996), glosses these roughly concurrent breakthroughs, and argues that they amounted to a seismic paradigm shift across the sciences.
[65] Lewis Thomas, *The Lives of a Cell: Notes of a Biology Watcher* (New York: Viking, 1974). See, in particular, the title essay, "The Lives of a Cell" (1-3) and "On Societies as Organisms" (9-13).

boundary between life and matter, sometimes in ways that seem decades ahead of their time, prefiguring the outlook of later scientific models.[66]

In puzzling over the fundamental properties of life (and life's vexing relation to matter), this earlier cohort of scientists worked from their distinct disciplinary backgrounds in ways that confronted ongoing paradigm disputes in the life sciences[67]—disputes between, on the one side, the techniques, concepts, and methods of cell science, and, on the other, those associated with the organism.[68] At their core, these disputes were about the level at which to define biological "individuals," and how to think about life's essential "building blocks."[69] Since Theodor Schwann's 1839 application of cell theory to all living things, there had been a biological consensus on the *existence* and ubiquity of microscopic cells.[70] But there were continual skirmishes between organismic scientists and cell scientists as to the extent to which cellular properties could explain life's macroscopic manifestations and, as a corollary to this, what share of scientific attention ought therefore to be dedicated to the physics and chemistry of cells, as opposed to the intricate behaviors of complex, fleshy organisms. The cellular paradigm largely overlapped with a mechanistic conception of life, according to which all vital phenomena must be determined by confederations of the cells.[71]

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[66] David Aubin, "'The Memory of Life Itself': Bénard's Cells and the Cinematography of Self-Organization," *Studies in the History and Philosophy of Science* 39 (2008), 360; on Leduc, see Evelyn Fox Keller, *Making Sense of Life: Explaining Biological Development with Models, Metaphors, and Machines* (Cambridge, MA: Harvard University Press, 2002).
[67] Poincaré was a mathematician, Bénard and Leduc physical chemists.
[68] Andrew Reynolds, "The Theory of the Cell State and the Question of Cell Autonomy in Nineteenth and Early Twentieth Century Biology," (2007), 73; Garland Allen, "Mechanism, Vitalism and Organicism in Late Nineteenth and Twentieth-Century Biology: The Importance of Historical Context," *Studies in the History and Philosophy of Science* 36, no. 2 (2005): 261-83; William Emerson Ritter, *Unity of the Organism, or the Organismal Conception of Life* (Boston, MA: The Gorhan Press, 1919).
[69] Richard Lewontin, "Foreword," *Organism and the Origins of Self*, ed. Alfred I. Tauber (Dordrecht, Netherlands: Kluwer Academic Publishers, 1991), xiii.
[70] Georges Canguilhem, "Cell Theory," in *Knowledge of Life*, ed. Paola Marrati and Todd Meyers, trans. Stefanos Geroulanos and Daniela Ginsburg (New York: Fordham University Press, 2008 [1965]), 25-56.
[71] Jacques Loeb, *The Mechanistic Conception of Life* (1912).

This approach is thoroughly reductive, seeking to break complex macroscopic phenomena down into discrete, ultimately microscopic, quasi-mechanical components, so the business of biology boils down to analyzing the properties of cells, assuming all the while that questions about wholes should be referred to their aggregated parts.

The traditional alternative to these sorts of mechanistic, analytic approaches had long been some version of vitalism: denying the cellular hypothesis by positing some immaterial, metaphysical remainder, some extra property or principle beyond the chemical reactions that describe the mechanics of the cell.[72] The centrality of the *organism* appeared as a sort of third path between the mechanistic tendencies of cytology and the methodological dead ends of vitalism.[73] As scientists at the start of the twentieth century outlined the promise of an *organismic* or *organismal* approach, they did not claim some insubstantial or spiritual supplement that exceeded a given body's cellular composition, but instead stressed the *arrangement* itself—*how* cells were confederated, arranged into subsystems, subsumed into a fleshy body's vital infrastructure. To see the organism at all was to see how these arrangements and patterns served a biological entity that did not properly exist in any of these cellular parts, nor in their arithmetic sum; it was to see the peculiarly self-oriented nature of the organism's energy and organization. Alfred North Whitehead characterized the organism as "a unit of *emergent* value"—one, that is, whose definitive properties described,

[72] The history of vitalist doctrines has at times been treated as a retreat from empiricism, a reactionary rejection of modern scientific advances—a form of anti-scientific metaphysics, even, adopted by philosophers and other scientific outsiders. However, there were a number of respected scientists who defended vitalist positions, or otherwise resisted the tide of mechanistic ideology. See Allen, "Mechanism, Vitalism and Organicism"; and Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC: Duke University Press, 2009).
[73] Tauber, "Introduction: Speculations Concerning the Origins of the Self," *Organism and the Origins of Self*, 26. Even by the end of the twentieth century, Tauber suggests, biology had still not resolved the philosophical antinomies of the early 1900s, and had still not followed through on the integrative possibilities of an organismic approach: "a science of *organism* has not developed, where the laws of organization and hierarchy have been sought as a *primary* focus of biology."

not individual constituent elements, but the way in which these elements came together into a greater whole, a "selective activity which is akin to purpose."[74] Teleology was unavoidable in such an approach: to *reduce* the organism's self-sustaining and self-referring energies to the rudimentary agencies of discrete cells was, in fact, to refuse to perceive the organism as such. The organismic paradigm accordingly required a willingness to ascribe purposefulness to the organism, and champions of organismic biology framed this purposefulness as a matter of heuristics. The difference between the cellular paradigm and the organismic was, quite literally, a matter of *perspective.* Making the organism a basis of biological methodology meant acknowledging the organization of systems *within* the organism, and the dynamic, dialectical relationships between the organism and its environment.[75] It meant, methodologically *and* perceptually, seeing and recognizing these relationships.

As paradigms for the study of life, the cell and the organism implied different destinies for biology—different objects of inquiry, different models of explanation, different conceptions of life. Perhaps most basically, they implied different observational protocols, different ways of beholding vital phenomena—literally (through advances in optical media) and metaphorically (through analogies with social organization). Hilary Harris's speculative comparison of city and organism was, in many ways, an update on an idea that was at least as old as the notion of the cell itself, and which was just as often applied to understandings of the organism. The cell came into conceptual being through metaphoric links to statecraft: Rudolf Virchow, one of cell theory's earliest exponents, is likewise credited with originating one variant of the "theory of the cell state," according to which cells within a complex organ

[74] Alfred North Whitehead, *Science and the Modern World*, 151-2 (my emphasis). Quoted in Tauber, "Introduction," 28.
[75] Tauber, "Introduction," 29.

were like "citizens" configured into a larger social colony.[76] Variants on this theme of the cell as an individual within a larger (social) body were put forward by Ernst Haekel and Herbert Spencer, among others, often with the aim of explaining the rational, cooperative construction of the organismic body, but at least as often intent on divining political lessons from biology's apparently harmonious, "natural" settlement of competing cellular interests.[77] As Georges Canguilhem and Richard Lewontin have pointed out, while these analogical constructs were often presented as biology coming to the aid of social and political theory, the formation of cell theory in many ways *co-evolved* with theories of the individual and the nation-state. "The history of the concept of the cell is inseparable from the history of the concept of the individual," writes Canguilhem, and so we need to acknowledge how "social and affective values hover above the development of cell theory."[78] Metaphors are, in their own way, instruments of inspection, media that shape the scientist's perception and understanding of the phenomena she views. The cell and the organism, and the dynamic between them, could only be seen or thought against the background of this symbolic, metaphoric preparation. The relationships between cells and organisms (and species and societies) demanded acute strategies for imaginatively bridging disparate scales of being, making "questions about the existence of different levels of organization a major theme within the biological sciences."[79] These strategies harnessed the power of metaphor—especially metaphor animated and conditioned by new optical technologies—to forge creative links between superficially dissimilar things.

[76] Reynolds, "Theory of the Cell State," 71.
[77] Reynolds, "Theory of the Cell State," 72-5; Spencer, "The Social Organism," (1860); Oswei Temkin, "Metaphors of Human Biology," in *Science and Civilization*, ed. R. C. Stauffer (1949).
[78] Canguilhem, "The Cell Theory," 62.
[79] Reynolds, "Theory of the Cell State," 72-3.

Scale-shifting, in short, was as central to the scientific conceptualization of the organism as it would be for filmmakers attempting a coherent picture of the modern metropolis. In both cases, working across scales involved a dialectic of metaphor and optical media. As an example of how the biology of cells (and organisms) turned upon this complex of observable phenomena, scale-shifting metaphor, and visual media, recall the case of the cell's conceptualization. The story of the cell begins with Robert Hooke's tinkering at his microscope, inspecting a thin slice of cork and musing (in his *Micrographia*) that under magnification the material resembled nothing so much as the schematic partitioning of a honeycomb, or a series of vacant rooms, or *cells* (this microscopic vacancy, he reasoned, accounting for cork's lightness and buoyancy as a tangible substance).[80] The word "cell" did not gain traction among Hooke's contemporary micrographers, and so lay dormant for a generation before being revived in the 1800s and integrated (with its embedded association with bee societies and monasteries) into an emergent theory of life's basic, universal structure. The theory itself may (like atomic theory) have been thinkable without the visual corroboration it received through the microscope and without the metaphoric baggage of honeycomb and human living quarters. But without the testimony of embodied, metaphor-laden eyes, the theory would not have had the *character* it did, especially its entanglement in thoughts about the subsumption of individuals by a collective, as figured by beehives and modern political structures.[81] That Hooke's idiosyncratic word choices (calling these structures "Cells" or rooms or "Pores" in a honeycomb) for these vital compartments has stuck all these years is a testament to how an initial metaphor-guided perception was later

[80] Robert Hooke, *Micrographia*, 113.
[81] As Canguilhem puts it, "It is the eyes of reason that see light waves, but it certainly seems that it is the bodily eyes, the sense organs, that identify cuts in a plant cutting." *Knowledge of Life*, 29. The distinction gestured at by "eyes of reason" as opposed to "bodily eyes" is between a *theoretical* science and an *experimental* one.

baked into the imaginative force of a biological concept, priming it for other, increasingly elaborate sorts of scale-shifting analogies within and across the spheres of biology and politics. Metaphor conditioned the view through the microscope, and the circulation of microscopic imagery continued to trigger increasingly speculative metaphors. It is unsurprising (and, perhaps, unavoidable), then, that the tension between cellular and organismic approaches (and the shift in metaphoric weight implied by each) would continue to be disputed through associations and qualities afforded by other optical instruments, as these emerged—up to and including motion pictures.

Moving images, including the dramatic example of time-lapse photography, quickly became important touchstones in the conceptual confrontations underway in the life sciences of the early twentieth century. As Scott Curtis has pointed out, the fact that time-lapse imagery was so readily adopted and applied in various branches of science (not just in botany and embryology, but in physics, crystallography, and chemistry too) speaks to how time-lapse's technical characteristics were already suited to the logic of experimental science at that moment. The rigidly spaced intervals between exposures, time-lapse's "linear regularity," readily appealed to modern science's growing penchant for statistical sampling as a way to produce a representative, "overall" profile of a given phenomenon. But if the time-lapse image was technically obedient to certain of science's dominant protocols, its experiential splendor could nevertheless inspire new directions in research: "Time-lapse cinematography can, for example, confirm an understanding of nature as regular and divisible, but it also offers a surprising, even thrilling new image that prompts new

questions."[82] This *suggestiveness* of time-lapse imagery, and of the apparatus's technical correspondence with the phenomena it rendered, seems to have been particularly intense among biologists. Cell scientists like Alexis Carrel and Julius Ries, for example, felt that seeing time-lapse films of cell activity would convince students of the truth of the cell theory in a way that no other medium could (including the pedagogical mainstays of static microscopic slides), inspiring a feeling of physical *proximity* conditioned, paradoxically, by the technical intermediary of the cinematograph. "One really believes one has a living, developing egg before one," confessed Ries, evoking a mystical experience which sensually confirmed an otherwise theoretical process, and which also "revealed to us that which we had never suspected."[83] Seeing cellular phenomena not as isolated and static slides, but as unfolding and autonomous displays, seemed to demonstrate, with the force of perceptual faith, the independent and self-sufficient life of the cell. That these images were produced through an automated device also seemed to validate the cytologist's analytic perception—that the mechanical parsing of life's complex expressions into constituent slices could, like a Riemann sum, ultimately capture and reproduce all their essential features.

On the other hand, for researchers more interested in apprehending organisms on their own, organismic terms, what was crucial about time-lapse cinematography was the technique's potential to modulate time in tune with life's inconstant, non-mechanical vicissitudes. Time-lapse techniques were, in this sense, bound up with the philosophical aura of modern biology, represented both by Henri Bergson's vitalism and, later, by Du Nüoy's

[82] Scott Curtis, *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany* (New York: Columbia University Press, 2015), 23.
[83] Ries, quoted in Hannah Landecker, "Microcinematography and the History of Science and Film," *Isis* 97 (2006), 126, 125.

notion of "biological time."[84] "Biological time" was a philosophy of life premised on the notion that live flesh and dead matter encoded time in fundamentally different ways, and that these differences became manifest as different qualities of perceptible movement. The testimony of the eyes was once again central to drawing crucial scientific distinctions: as Bénard (skeptically) observed, our conviction that living things differ from merely mechanical systems is based in the impression that their movements *look different*.[85] At an even more basic level, as Jimena Canales has observed, the question "*What is life?*" was largely converted into the question "*What does life look like*?"[86] Motion pictures were understandably appealing to scientists working within this evaluative frame, as they were able to record (as no other durable scientific illustration could) the living organism's essential movements, and to discover, via time-lapse and slow motion, others that were normally imperceptible.

When Alexis Carrel declared that "cinematography alone" was adequate to registering life's essential attributes, the implication was that the film medium was not merely *apt* to discriminating important distinctions, but was a medium whose functioning was itself homologous to the logic of the organism. Carrel was convinced that, because film technique included the ability to modify frame rate—to modify the rate and regularity of time's photochemical encoding—it was like, and therefore suited to conveying, the inconstant vital rhythms of the organism. It was possible to film "according to the activity of the culture," altering exposure intervals to compensate for (or amplify) the irregular rhythms

[84] Bergson's *Matter and Memory* and *Creative Evolution* are the two classic texts laying out this version of vitalism. On biological time, see Pierre Lecomte Du Nüoy, *Biological Time* (New York: MacMillan, 1936).
[85] Canales, "Dead and Alive: Micro-cinematography between Physics and Biology," *Configurations* 23, no. 2 (2015), 238.
[86] Canales, "Dead and Alive," 235.

of a growing tissue culture.[87] If (as Hannah Landecker has suggested) the tissue culture was itself a sort of cyborgian technology, an instrument for studying properties of life, then time-lapse films could be read as remediations of that technology: efforts to reproduce, on filmic terms, the essential features of the cellular medium.[88] In film, after all, one beheld an unstill image that synthesized cellular units into a vital and animated *whole*, a whole irreducible to the spatial accumulation of celluloid "cells," or to the independent functioning of the projector. This cinematic assemblage, moreover, also solicits and depends upon the evolved idiosyncracies of human perception: it is, after all, only a quirk of human vision that transmutes twenty-four frames per second into seamless, phenomenal motion. Both in the imagery put on display and in the mythic implications of the medium itself, time-lapse techniques inspired reflection on the core properties of the organism: its distinct forms of integration, purposefulness, part-whole interdependence, and homeostasis.

Time-lapse imagery spoke simultaneously to two competing interpretive paradigms. Its automatic basis encouraged confidence that life forms could be exhaustively analyzed along mechanistic lines, corroborating the cellular hypothesis. On the other hand, the technique's temporal malleability and integration with human perception embodied the holistic agenda of organismic biology. This "ambidexterity," as Curtis terms it, reflects how visual media in general have participated in defining the means and ends of modern biology, especially in the early twentieth century. Definitions of life largely depended on the conditions in which lively movements were *perceptible*, so that the emergence of cinema coincided with questions about the multiplicity of scientific *gazes*, beyond the singular ideal

[87] Alexis Carrel, "The New Cytology" *Science* 73:1890 (1931): 300. Quoted in Canales, "Dead and Alive," 247.
[88] Landecker, *Culturing Life: How Cells Became Technologies* (Cambridge, MA: Harvard University Press, 2007). Landecker has similarly remarked on the suggestive significance of the word "medium" within microbiology.

of objective observation. Hugo Münsterberg had remarked, in 1916, at how cinematic technologies, techniques, and conventions mimicked (*and* solicited) corresponding faculties of perception—the close-up, for instance, embodying an act of attention, or a flashback modeling the mechanics of memory.[89] By the same token, modifications of the apparatus for the sake of experimentation had a complex relation to expert modes of perception: not only did they produce an enhanced image of recalcitrant objects, but they stood in for, and allowed a form of access to, the scientist's observational labors. Time-lapse techniques reinforced the centrality of *time* to the progress of experiment, addressing the extreme patience and singular attention demanded by slow-moving and -developing phenomena, underscoring (by obviating) the laboriousness of this way of looking, and thereby "allowing people other than scientists to participate visually in the sights of scientific work and the mode of experimental looking."[90] As Landecker points out, this shift in emphasis from the revelation of unseen "things" to extending access to "how scientists see things" dovetails with a related distinction, between rendering something *visible* and making it "more real."[91] But *within* the discipline of biology, this power to consolidate or vivify a given gaze could also frame competing disciplinary agendas, especially if a given technique mimicked (or solicited) a more singular, analytic, cellular form of attention, or if (conversely) it corresponded to a holistic, analogical, organismic perception.

How, then, does time-lapse fit into these disputes, and how might Harris's later experimentation with time-lapse articulate them differently? On the one hand, time-lapse imagery (especially in microcinematographic films of cells and embryos) tends to isolate

[89] Hugo Münsterberg, *The Photoplay: A Psychological Study* (New York: D. Appleton and Company, 1916).
[90] Landecker, "Microcinematography and the History of Science and Film," 123.
[91] Landecker, "Microcinematography and the History of Science and Film," 127, 129.

living bodies from their environments, inquiring into their solitary and independent machinations, applying an intense and concerted gaze to this partial object in the expectation of having some share of life's essence disclosed to us. If we reflect on the experimental labor at stake in these time-lapse images of division and development, the filmmaker-scientist's effort is largely to replace a spatial context with a temporal one. In watching an embryo develop, for instance, what is abstracted from the static spatial frame is a sense of the external factors that contribute to this development—the mother (if we are viewing a mammal, for instance) into whose womb we are effectively peering; her diet and activities; her interactions with an environment generally seen as critical to fetal development.[92] In place of these determinants of spatial environment, we get a picture of independent development shaped only by the passing of time, the part's subsumption in the eventual whole, a picture of ineluctable progress.

This way of envisioning life is certainly compatible with the principles and priorities of cell science—the preeminence of minute analysis, the sufficiency of the basic unit to explain the corporate whole—but the aesthetic and ethical virtues it engenders are those that define the organism. In large part, time-lapse's aesthetic and technical profile enabled it to mediate between cellular and organismic paradigms. The technique served the agendas of scientists inspecting the isolated cell, but it also provided a visual syntax for principles of holism and the complex interconnection of vital parts. In imaging cellular life, we replace drawn illustrations depicting the stages of development with a *developing* image.[93] We are

[92] The tendency to obscure motherhood (and other dimensions of gender) is remarked, in a different context, by Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis: University of Minnesota Press, 1995). See also Janina Wellmann, "Animating Embryos: The *in toto* representation of Life," *British Journal for the History of Science* 50, no. 3 (2017): 521-35.

[93] To distinguish an image *of* development from a *developing image*, one might, with a nod to Deleuze, call this a *development-image*.

induced to experience development as a continuous process, investing our observation in "the ordered, directional change manifest during the life of individual organisms as they develop from a single fertilized egg into complex patterns of different yet interacting cells, tissues, and organs."[94] The image's fixed spatial frame may exclude mother and environment, but its generous temporal frame allows other forms of integration to gain aesthetic footing: namely, the dialectic of unity and multiplicity that binds the zygote to the cellular colony it becomes; the symmetry and order that preside over these continuous transitions; the elegantly repeating patterns of division and grastulation; the visible "interdependence of structures and functions"; the emergence of successive forms, and the *cinematic* form described by the course of this emergence.[95] As Scott Gilbert and Marion Faber argue, the discipline of embryology consolidated around the wonderstruck experience of beholding development, drawing inspiration from a body of aesthetic principles while also contributing to them through the conceptual appeal of morphogenesis—a distinct aesthetic of *emergent form*. The gaze associated with this visual-conceptual apprehension was one that was open to speculative analogies, binding minuteness to vastness in the image of the continuously developing germ. As one early embryologist put it, "The egg cell is also a universe."[96] To this extent, the aesthetic of embryology held much in common with what Michael Hau calls the "holistic gaze" of medical science around the turn of the twentieth century—an aesthetically infused mode of observation that stressed the physician's "ability to 'see' and to synthesize seemingly fragmented characteristics of a human body into an aesthetic, coherent,

[94] Scott F. Gilbert and Marion Faber, "Looking at Embryos: The Visual and Conceptual Aesthetics of Emerging Form," in *The Elusive Synthesis: Aesthetics and Science*, ed. Alfred I. Tauber (Boston: Kluwer Academic Publishers, 1996), 126.
[95] Gilbert and Faber, "Looking at Embryos," 126. See also Nick Hopwood, "Producing Development: The Anatomy of Human Embryos and the Norms of Wilhelm His," *Bulletin of the History of Medicine* 74.1 (2000): 29-79.
[96] Just, quoted in Gilbert and Faber, "Looking at Embryos," 127.

whole."[97] While such a way of seeing was a way for professional physicians to assert their expertise, defending their elevated status against new optical technologies that threatened to supplant them, the values investing this holistic gaze are largely those of the time-lapsed embryo and of the concept of the organism.

Time-lapse photography was bound up with a vision that was at once penetrating and synoptic, embodying a way of seeing that was also a mode of understanding. It "operationalized a way of thinking," giving aesthetic form to the distinguishing features of the organism concept, and sketching the "principles of observation" proper to that object of study.[98] Central to both the objects of biological inquiry and to their aesthetic presentation was the notion of *rhythm*. In picturing development, time-lapse techniques could involve the viewer in the aesthetic contours of the *movements* integrating the organism's "stages," unspooling the rhythms at the heart of life, and discovering (not projecting) these rhythms *in* the observed embryo. Rhythm was one of the time-lapse camera's distinct and consistent discoveries, distilling it from urban and cellular phenomena alike. As Michael Cowan has shown, rhythm was central to cinema's imaginative congress with life, a subject thematized repeatedly in Weimar doctrines on film aesthetics as well as in physiology treatises and critiques of industrial labor. At the same moment that Kracauer first viewed and critiqued Ruttmann's *Berlin* on the grounds that it trafficked in superficial rhythms and analogies, rhythm was considered a principle that bridged the technical basis of film, the aesthetic forms of motion pictures, and the scientific understanding of the body. For Hans Richter, rhythm was nothing less than "the inner nature-force . . . through which we are bound up with

[97] Michael Hau, "The Holistic Gaze in German Medicine, 1890-1930," *Bulletin of the History of Medicine* 74, no. 3 (2000): 495-524. Quoted in Curtis, *The Shape of Spectatorship*, 120.
[98] Curtis, *The Shape of Spectatorship*, 124, 122.

elemental nature-forces"[99]—a primal medium of connection, a basis on which we could stake our internal communion with our environment (indeed, with the cosmos), and thus "a direct route to the spectator's emotional life."[100]

Considering the scientific, aesthetic, and cultural resonance of the notion of rhythm, Cowan responds to Kracauer's critique of Ruttmann's *Berlin*, noting that whereas Kracauer saw the city's cinematic rhythms as an elaboration of form at the expense of substantive commentary, these same rhythmical concerns can be seen as measured to the task of representing the conflict between natural rhythms and mechanical ones, a form meant to articulate how humanity's organic *Rhythmus* is increasingly fettered and conscripted by the city's rigidly metrical, clockwork *Takt*. Rhythm's cross-disciplinary circulation allowed it to serve as a conceptual interface between fields of inquiry, and aligned film's significance with the medium's power to engender the sorts of *visual rhythms* that Ruttmann pursued. These rhythmic figures allowed him (in *Berlin* as in his earlier abstract animations) to give (in the words of his contemporary, Käthe Kurtzig) "visible expression to an intellectual content through the movement of ornaments and figures; it works above all through the rhythmical power of movement, which brings the spectator into resonance with its movements . . . and allows him not simply to see and understand events on the screen, but also to experience them."[101] Even when Ruttmann's compositional rhythms, his temporal figures, express the rigid and domineering regime of modern industry, their visceral appeal is always a token of our *organic* attunement with the medium rendering them. We respond emotionally because

[99] Quoted in Michael Cowan, "The Heart Machine: 'Rhythm' and Body in Weimar Film and Fritz Lang's *Metropolis*" *Modernism/modernity* 14, no. 2 (2007), 227.
[100] Cowan, "The Heart Machine," 227.
[101] Quoted in Cowan, "Absolute Advertising: Walter Ruttmann and the Weimar Advertising Film," *Cinema Journal* 52, no. 4 (2013), 61.

our sensorium intuitively understands the language of visual, rhythmic movement; it addresses, and reminds us of, our bodies' organic endowment, our *organismic* embodiment of environmental pulses and ecological cycles.

It is important to distinguish the appeal of a *discovered* rhythm from rhythm as an editing effect—the sense that the motion picture camera has rooted out and revealed a form of worldly rhythm, as opposed to feeling that profilmic reality has been digested and repatterned to serve a narrowly artistic agenda. Discovered rhythm is integral to the experimental impulse of city films, and to the sort of light they shed on urban life. The city symphonies' much-remarked predilection for rhythmic patterns was, by this token, a way to read—better yet, to *experience*—the city's orchestration. This line of filmmaking sets up aesthetic experience as a way to take the city's pulse, divining the health or sickness of this variegated assemblage—whether living inhabitants and technic infrastructures are harmonized and integrated, or whether their coincident movements are, instead, fractious and dissonant, or whether the citizenry has been rendered mechanical by its inorganic environment. There is an affinity between this way of envisioning the city and the observational ethic Hau associates with medicine's holistic gaze circa 1900—especially as those holistic principles were concurrently emblematized by time-lapse studies of embryos and cells. Where one cinematic strategy assayed the city as body politic, the other anchored itself to the body as an abiding, biological whole.

We should, in light of this affinity, revise the terms of Kracauer's complaint with *Berlin* and its formalist ilk. In portraying the city as a weave of rhythmic patterns, these films don't exactly sidestep politically trenchant commentary; rather, their formalism can be defended as accessing politics at a different level of expression, activating cinema as a

hybrid, techno-physiological medium. The discovery and elaboration of varied visual rhythms promises to involve the viewer empathically in the city's dynamic forms, enticing her to compare, judge, and perhaps align her emotional response to the cinematic movements she beholds. This empathic linkage also invites us to reframe the question at the center of Harris's *Organism*, viz., whether and how the city resembles the human body's vital physiology. Rather than couch such comparisons in some objective standard, we can focus on how the comparison of city and organism depends, first of all, on a peculiar way of seeing—an *organismic gaze*.

Organism and Organismic Vision

In my earlier, provisional reading of *Organism*, I considered how Harris uses time-lapse as a rhetorical device, helping him establish the film's speculative thesis: that the city is (or is *like*) an organism. Focusing on rhetoric in this way helps us appreciate time-lapse photography as an instrument of persuasion, a technique that aids Harris in illustrating his thesis and working on his audience's emotions, making us receptive to what might otherwise seem a flimsy or banal analogy. Acknowledging the common-sense view that neither film technologies nor techniques are ideology-laden in the way 1970s film theory sometimes said they were,[102] I would like to consider how a technique (like time-lapse photography) nevertheless continues to reflect the intentions and values that spurred its original invention, and how these historically accumulated values influence or illuminate the character of their later applications. For my own purposes in thinking about the rhetorical employment of time-lapse techniques, I would like to take seriously the notion that the camera can serve not

[102] This view is painstakingly laid out and defended in Noël Carroll, *Mystifying Movies: Fads and Fallacies in Contemporary Film Theory* (New York: Columbia University Press, 1988).

just as an expressive implement, but also as an *instigator* of discoveries. How does this appreciation of the camera as epistemic *agent* ramify through our reading of a film like *Organism*? What else is there to say about this film, if we acknowledge camera technique as contributing actively to perceptual, aesthetic, and/or political illumination, or as animating the joints between them?

The last two sections have described how poetic city symphonies and microbiological films refined time-lapse techniques to investigate complex expressions of life—how, in these radically distinct institutional contexts, working with time-lapse photography was one way in which filmmakers produced experimental knowledge. This claim is potentially contentious in the case of aesthetic-minded city symphonies, but it is probably obvious in the case of research films. On the other hand, I have suggested that the aesthetic qualities of these latter science films—the emotional experience of beholding imagery of embryos developing and cells twitchily dividing—are *also* part of a structure of experimental knowing. The technique, then, both produces, and in some sense *models*, the form of knowledge with which it is associated; it grants us new access to vital phenomena, while also telling us what sort of thing "life" is. Turning to *Organism* once again, I want to reconsider the film in light of these earlier contexts of time-lapse experimentation—the city symphony and the cellular research film—both of which become manifest in the structure and imagery of Harris's film.

One way to motivate such a rereading would be to consider the generative ambiguity, for film theory and criticism, of the notion of the organism. Even as twentieth-century biologists reappraised vital phenomena in response to cinematic renderings of them, early film theorists were similarly impressed by science films: film was made to serve the disciplinary agenda of the sciences, but so were scientific iconographies absorbed and

adapted to the work of theorizing the movies. Eisenstein, the great champion of montage, may have said that the isolated shot was "single in meaning, neutral in content"; but he also speculated (likely in response to science films of cellular life) that cinema's essential units were not inert "bricks" to be stacked and mortared into a sturdy and rigid structure, but lively "cells" that bonded together in chains of interdependence, accumulating into a dynamic, restless, self-articulating *organism*.[103] Harris's film seems to operate under a similar conceit. The "organism" named in the title is not *just* the boisterous city, nor is it *just* the animal bodies whose interior functions we observe in the medical footage. *The film itself* is supposed to be an organism of sorts: a cooperative assemblage of medical and urban imagery, of diverse views which coalesce to form a complex whole greater than the sum of its celluloid parts.[104] In relation to this intricate cinematic assemblage, how do we position *our* constitution as organisms—our evolved perceptual faculties; our visceral responses; our empathic stake in what we behold? Might we continue stretching the skin of "organism" concept, so that our empathic response is part of the film as an organismic complex, the very medium, even, through which cell, body, and city are integrated? This gambit would stake our power to see and feel analogies across disparate scales as, itself, a form of evidence of actual relationships—or, at the very least, it would acknowledge our penchant for analogy as an important part of the plenum of life. In re-reading *Organism*, I want to consider how the film engenders a way of seeing that corresponds to the attributes and logic of the organism—an *organismic vision*. This organismic vision stands behind the equation of the metropolis

[103] On the influence of popular science films (especially time-lapse films) on the imagination and vocabulary of early film theorists, see Hannah Landecker, "Cellular Features: Microcinematography and Film Theory," *Critical Inquiry* 31, no. 4 (2005): 903-37.

[104] I take MacDonald as making a similar connection between film form and organismic integration, when he writes that the film transforms "the cycles of dawn to dusk to dawn into visual cells within a larger cinematic organism . . ." *The Garden in the Machine*, 169.

with a biological body; but it is realized most fully in the experimental impulse that produces this material for visual analogizing.

I have spoken of the city symphony as a hybrid, modernist subgenre whose internal development is in large part driven by the impulse to tinker with camera equipment, often in ways that make equipment a fulcrum for modifying film form. In Harris's case, to speak of his "experimental impulse" is to highlight his affiliation with the New York experimental film community of 1950s, '60s, and '70s. Harris worked both commercially and independently, placing him in the orbit of figures like Stan Brakhage, Jonas Mekas, Maya Deren, Michael Snow, Ken Jacobs, Jack Smith, and Andy Warhol, all of whom were active in New York's "underground" film scene in the decades when Harris was working. In writings and interviews, Harris echoes the ideas and values proclaimed by this community of film artists working independently from (and in many cases against) the industrial primacy of Hollywood. He speaks of the need for filmmakers to find and develop an intrinsically "filmic" form for their films—a form, that is, which would owe nothing to literature, theater, or the other arts. In the same breath, he grants that what is distinctive about film may be, after all, its "extraordinary" facility at "borrowing and using the images of all the other arts."[105] In particular, Harris bases film's transformative power in a universal ontology of *movement*: movement is a principle that binds together diverse phenomena, discerning the identity and meaning of each and every thing: "Out of our eyes all things move and express themselves in their movement. . . . from the flick of a cat's tail to the majesty of the earth's rotation. . . . every movement expresses something."[106] The world speaks to us in a language

[105] Hilary Harris, "Thoughts on Movement," in *The Movies as Medium*, ed. Lewis Jacobs (New York: Farrar, Straus & Giroux, 1970), 90.
[106] Harris, "Thoughts on Movement," 90.

of movements, Harris seems to be saying, a language whose nuances and inflections cinema is apt to capture and interrogate. Cinema *is* a fabric of movements, and it is an instrument for mediating worldly movements.

In films like *Highway* (1958), Harris shows his sensitivity to various forms and senses of movement, and tests their availability to cinematic capture—the rush of vehicular traffic *past* the camera, and the propulsive thrill of having the camera rush through space at sixty miles per hour. But his commitment to cinema as a medium of movement is most powerful in his elegant and thoughtful approach to camera movement. Harris's camerawork is unusually polished even compared to his cohort of North American independents—his pans and zooms smooth and professional, his alterations of focus careful and deliberate, his framings thoughtfully composed. Harris found ways to combine his technical mastery and professionalism with experimental forms that articulated and foregrounded his body behind the camera, hefting it, pointing it, responding with it. In *Highway*, he responds not only to the dramatic movements of traffic through the camera's plane of vision, but also to the complex concrete infrastructure that enables these commutes. Set to an upbeat jazz score, Harris converts the seemingly static elements of this built environment—the round reflective markers dividing lanes; the curved topography of overpasses viewed from below; the linear reach of the siderails—into forms that not only guide the behavior of motorists, but which suggest corresponding forms of camera movement and editing. The overpasses call out for arcing swoops of the camera, as if receiving their motive force from shape of the structure. The braille-like lane dividers settle into repeating, percussive rhythms as the camera speeds past them—rhythms which the film reproduces as repeating, syncopated editing patterns. Here and elsewhere, Harris's experimental ethic was focused on this discovery of dynamic

equivalents, of counterparts in the language of film (which, for him, was a language of live and embodied movements) for whatever forms one might find in the world.

Organism was to be one segment of a larger, feature-length New York film, for which Harris had received support from the National Endowment for the Arts and the Rockefeller Family Fund. He proceeded to gather footage intermittently over nearly seventeen years (as time and finances allowed) before finally completing an edit of *Organism*. Over the course of this prolonged shooting schedule, it also seems that Harris's process was unguided and open-ended, at least at first. His goal was just a vague directive to explore the city with his camera, to compile an archive of images he could later give shape, coherence, and argumentative force; his thesis, to the extent that he had one, was that "the city is beautiful."[107] As with earlier city symphonies, *Organism*'s germ was the unrefined urge to document the city—an urge which, as Jacobson's account of film's "infrastructural affinity" attests, so often manifested as an impulse to tinker with film equipment, testing the medium's power to reveal (and be revealed *by*) the city anew. Before he hit upon the "organism" as a structuring concept for his New York footage, Harris embraced time-lapse photography as an optic through which to apprehend his urban milieu: time-lapse was, in other words, integral to the film's original basis, its experimental impulse, as if exploring the city and tinkering with frame-rate were congruent activities.

If exploration leads to orientation—or, better yet, to a tangible *map* of a given territory—what concrete results do Harris's time-lapse experiments yield? It has been said that *Organism* did much to reinvigorate interest in time-lapse techniques, especially if one

[107] Harris, interview with Robert Gardner, *Screening Room*, 1979.

considers its influence on (and through) *Koyaanisqatsi*.[108] But it bears asking where and how Harris's time-lapse work might have been truly *innovative*. Did *Organism* do anything with time-lapse techniques that hadn't been done as well or as memorably in earlier city films? For all that this film cites medical films and biology's institutional applications of time-lapse imagery, did Harris's own cinematographic experiments channel, modify, or improvise upon this scientific legacy in any meaningful way?

One aspect of *Organism* that evokes time-lapse's early medical settings, perhaps, is how *extensively* time-lapse techniques are used in the film. This salient and single-minded application of the technique recalls early microcinematographic studies—the camera's patient, prolonged observation of a gestating egg, determined to capture the cell's continuous divisions and idiosyncratic rhythms.[109] By making time-lapse techniques so prominent, the film channels this investigative protocol into an accumulative aesthetic: these high doses of accelerated imagery have the effect of ratcheting up our experience of the city's energy, gradually increasing its affective charge in synchrony with its cinematically quickened pulse. If the juxtapositions with medical imagery qualify as a sort of associative montage, drawing impressionistic analogies between different phenomena, the mounting momentum of the time-lapse imagery puts us in a position to draw *affective* connections. Departing from modern science's (likely overstated) paradigm of objective, disinterested observation (which standard may or may not be modeled by the time-lapse apparatus), we respond to this swirl

[108] Reggio ("Interview with Scott MacDonald"), of course, notes that he had decided to focus on time-lapse techniques *before* he was made aware of Harris's film. In this light, we could perhaps muse that the mid-70s were simply *ripe* for this return to time-lapse techniques in the name of promoting ecological consciousness; or, we could frame *Organism*'s influence on *Koyaanisqatsi* as validating Reggio's initial intention, and suggesting specific ways of utilizing time-lapse imagery—evocative iconographies, effective stylistic gestures, and so on.
[109] This concerted use of time-lapse techniques also stands in contrast to time-lapse's brief and sporadic appearances in contemporary fiction films, where it is coded to convey the passage of time, as a bridge between scenes, or as an establishing shot, commanding no more attention than a wipe or a dissolve.

of medical and urban phenomena as passionate witnesses, bodily implicated in what we see. Hailing us as biological beings, the film at the same time challenges us to see ourselves as molecular participants in the social-technological body we behold. Time-lapse's "mobilization of affect" (as Sean Cubitt has called it) is in this sense motivated by a sort of organismic logic.[110] Perception, we are reminded, depends upon and is part of this organic, ecological scheme. In short, we are supposed to *feel* this identity of micro- and macrocosm; not just to cognize life's interrelated scales of organization, but to *experience* our entanglement in them.

These affective investments complement the other ways in which time-lapse techniques enable formal analogies between social and bodily systems. Time-lapse, as we have seen throughout this project, often defamiliarizes its subjects, altering the temporal (as well as spatial) conditions under which we customarily encounter them. We see our familiar environment in a new light—inert minerals swell and crystalize before our eyes, slime molds ripple and writhe, vines grope and explore the space around them—and, being so lifted out of routine associations and understandings, these newly mobile objects prompt us to envision new modes of connection between them (and between them and us). In many cases, we become attuned to abstract, overall patterns at the same time that the image glosses away any individuating textures and details—a visual tendency that extends time-lapse's technical embodiment of the representational logic of statistical sampling.[111] In a film like *Organism*, individual people and objects melt into larger collectives, just as the mail service sorts and collates scattered individuals into systematic networks. Time-lapse accelerations contribute

[110] Sean Cubitt, "Everybody Knows this is Nowhere: Data Visualization and Ecocritcism," in *Ecocinema Theory and Practice*, ed. Stephen Rust, Sama Monani, and Sean Cubitt (New York: Routledge, 2012), 277-296.
[111] Curtis, *The Shape of Spectatorship*, 113

to this blurring of individuality into collective process, but as compensation for this loss of grain we are able to perceive other dimensions of social reality: the repeating patterns of movement that come into focus through acceleration, the complex rhythms and harmonies of movement we are normally ill-positioned to appreciate. This emergence of kinetic pattern deepens the graphic matches linking medical and urban imagery, intensifying our sense for these organismic affiliations.

Using time-lapse photography to add depth and vigor to formal comparisons is not a radical innovation, per se. Indeed, Menken's pixilation experiments in *Go! Go! Go!* have similar effects—not just of erasing the particular and the human from the film's frenetic temporal frame, but shifting temporal scale to suggest a switch in *optics*. The microscope and telescope, after all, stand as the ur-form of optical revelation, the prototype for the sort of "penetrative vision" Kracauer wanted from city symphonies. In speeding up the ritualized processions of workers, athletes, writers, and students, Menken discovers a temporal analog to the microscopist's adjustments of optical magnification: we see less of the personal efforts and feelings that go into these performances, but more of the collective patterns into which these efforts are canalized; less of the trees, but more of the forest. From this point of view, we absorb cumulative patterns as aesthetic forms—forms which raise timely questions about the higher functions and purposes served by our narrow pursuit of personal achievement, our determination to "get along." In this sense, Menken had discovered how time-lapse's facility with surface patterns counts as a "penetrating" vision of its own sort. It reveals a new aspect to familiar things, destabilizing our habitual absorption in the status quo.

Harris's time-lapse work extends Menken's formal discoveries, developing them through narrower, concrete technical innovations. For example, one unusual aspect of

Harris's time-lapse technique is his adjustment of frame rate *within* a single shot, sometimes gradually, other times in sudden, hiccupping starts and stops. In this way, Harris "ramps" a real-time city scene so that the pace of phenomena quickens before our eyes, settling into, or jerking out of, a steady time-lapse speed. These dramatic variations remind us of the intervening apparatus and the prerogative of the filmmaker; they reinscribe his ability to modify the speed of things at will, according to what he wants (us) to notice, or inspect. But I would suggest that this "ramping," these propulsive accelerations and jerky diminutions of frame rate, also recalls the experience of examining specimens through a microscope. It is as if, through the time-lapse apparatus, the filmmaker is seeking for the optimal level of (temporal) magnification for the urban specimen arrayed before us. Time-lapse becomes a temporal analog not just to the *logic* of the microscope's spatial magnifications, but to that older device's conventions of use, its *phenomenology*—a technical experiment that puts the film spectator in the position of a viewer through a microscope. This articulation of time-lapse imagery conforms to the idea that it is the researcher's prerogative to modify time and space at will, depending on her research agenda and sources of interest. Harris's technique analogizes the principle of spatial malleability itself—which, as Hannah Landecker has argued, was integral to the logic of a scientific *gaze*.[112]

Harris's technical bravura is also marked in how he marries this tentatively scientific "way of seeing" to the conventional resources of film language, integrating time-lapse into cinema's formal grammar. Concretely, this can be seen in the technical marvels (to my knowledge unprecedented, or at least never this *elegant*, before 1975) of how Harris *moves* the camera while changing frame-rate—panning and tilting the camera within a time-lapse

[112] Landecker, "Microcinematography and the History of Science and Film," 123.

shot, varying focus and exposure, zooming in and out. One realizes, on reflection, the advantage of having some mechanical or computerized assistance in executing such maneuvers, so that the degree and steadiness of movement matches the gradualness of the sequential exposures.[113] These couplings of time-lapse and camera movement, especially when seen for the first time, can be striking and uncanny. In Harris's studies of Manhattan night life, it can seem as though the profilmic world already existed in this frenzied, time-lapsed state, and Harris is simply there with his camera to document it, tentatively pointing the viewfinder in one direction, then in another, then zooming in on some detail that catches his eye. As we process this uncanny perception of collective process—studying the familiar metropolis as though we were idly curious alien scientists—the intuitive effectiveness of these visions speaks to the extent to which this arranged marriage of time-lapse experiment and conventional film grammar has *worked*. This effective collapsing of the space between the alien and familiar, the experimental and the conventional, is a potent reminder that cinema's scientific and artistic vocations were never that far apart to begin with; that they were always bound to make a suitable couple, under the right circumstances.

As these selective examples suggest, Harris's technical innovations—his unguided tinkering with camera equipment, his improvisatory manipulations of his time-lapse rig, his directing of this apparatus at and around the enclave of Manhattan—correspond to altered ways of seeing. The in-shot manipulation of frame rate produces an optic of manipulability and experimentalist intervention. It models the phenomenology of the microscope and the scientist's scrutinizing, interventionist gaze. On the other hand, when Harris integrates time-

[113] Indeed, advances in computerization have made such flourishes of camera movement *within* a time-lapse shot commonplace in recent years. Automated camera rigs can be programmed so that the camera tracks only a few inches (or rotates only a degree or two) every hour, whereas executing such movements by hand would be an impractical strain on the camera operator's muscles and patience.

lapse photography with professional codes of camera movement, he bends this gaze to new objects, new tonal qualities, and new purposes, recovering and accentuating the aesthetic underside of microscopic spectatorship. In his bustling urban panoramas and roving rooftop surveys, the negotiation of cinematic space proceeds against the backdrop of a constant time-lapse speed. Instead of the microbiologist's interventionist gaze, these exploratory camera-movements evoke our implantation in an unfamiliar and independently evolving world. Time is no longer one of the experimenter's independent variables, a premise we may alter for the sake of rounding out our understanding of nature: instead, time is the token of a world we can gaze out *at* but never entirely access.[114] To see the world in this way is both thrilling and troubling, appealing to our senses and emotions, but insinuating that we are in fact dislodged from the world we supposedly inhabit. The ways of seeing betokened by Harris's time-lapse work, then, correspond to, and complicate, the visionary ethic of early biological applications of time-lapse techniques. They oscillate between the interventionism of a distinctly "scientific way of seeing," and the radically distinct, sublime mood in which we apprehend the self-coherence of a vital collective that both logically includes, and tonally rejects, *us* as individual and embodied viewers.

In suggesting that these (at times contradictory) ways of seeing nevertheless evoke an *organismic vision*, I stress the following principles that subtend this complex way of beholding. First: *Organism*'s organismic vision entails that what we behold demonstrates organic form—we see a system in which the parts contribute to the greater whole, and in which the whole has virtues irreducible to the sum of these parts. Second: This mode of

[114] Stanley Cavell, *The World Viewed: Reflections on the Ontology of Film*, enl. ed. (Cambridge, MA: Harvard University Press, 1979).

vision is thoroughly *embodied*. It enlists our empathic responses as part of the perceptual whole, integrating them with the physiological phenomena we see (even if, at times, this empathic involvement insinuates our remoteness from what we see). Third: This way of seeing means being particularly attuned to aesthetic rhythms and patterns. Fourth: This embodied perception of organic form and rhythm induces an attentiveness, an aliveness, to connections and correspondences across disparate scales of organization.

This reading of *Organism* does not fully answer the sorts of political objections that can be raised against the film—especially the impression that all this frenetic movement can paralyze the spectator, hypostasize the phenomena on screen, and naturalize the social order as we find it. Not wishing to downplay or deny these implications, what I have been trying to understand is the aesthetic sensibility that develops out of Harris's original *experimental impulse* (rather than the implications of his thesis per se)—the way he negotiates time-lapse photography's technical constraints, and how his inspired tinkering leads to formal discoveries and deeper, visionary possibilities. In (perhaps unintentionally) hitting upon a visual paradigm for our experiential remoteness from the city as a well-oiled machine, we can see how Harris's experiments prepare the ground for the dystopic vision of *Koyaanisqatsi*. The "Organism" implied by Harris's film is, again, not necessarily the city, or the biological systems to which it is compared, but the possibility or principle of meaningful comparison as such. The "Organismic" is, perhaps, this miracle of *perceiving* far-fetched correspondences across far-flung disparities of scale. Such a mode of vision is, indeed, aesthetic; but acknowledging this is not to downplay its significance to scientific progress. An aesthetically attuned vision seems to be integral to the organism concept, as it was formulated in relation to early time-lapse visualizations, and to the (unrealized)

discipline heralded by that concept. If we are skeptical about the value, to "hard" science, of indulging in life's intuitive beauty, this is perhaps a sign that the "organism" concept is indeed dead, or obsolete. This moment of obsolescence, then, is also precisely the occasion for appreciating the future that complexly mediated concept heralded, but was denied.[115] Regarding life from the posthuman vantage of the human genome project, we can better see that whatever was appealing and generative about the organism concept was bound up with the possibility of beholding life in this way—to take pleasure in its rhythms; to notice its analogies, synchronies, and harmonies; to attend to it aesthetically; to bear witness to the organism by embracing our own status *as* organisms; in a word: to see organismically.

[115] On Walter Benjamin's theory of obsolescence and its relevance to contemporary art, see Rosalind Krauss, "Reinventing the Medium," *Critical Inquiry* 25, no. 2 (1999): 289-305.

Conclusion: Meditations in an Ecological Emergency

The analysis I have offered of Hilary Harris's *Organism* (1975) is meant to shed some light on *Koyaanisqatsi* (Godfrey Reggio, 1982) too—*Koyaanisqatsi* being a film that crystallizes many of time-lapse photography's earlier applications, and whose legacy informs much of the technique's subsequent trajectory. Reggio's film, like Harris's, seems to promote a grand argument, poetic and visceral and intensely visual, concerning the nature of contemporary collective life. Like *Organism*, *Koyaanisqatsi* experiments with urban time-lapse footage to draw pointed analogies and contrasts, and to compose a wide-angle view of our globe-spanning civilization. By modulating film speeds, these two films help us perceive the infrastructures of modern, everyday life from an alternative perspective—a perspective in which new phenomena come into focus, new emotional connections become sensible, and different forms of living become thinkable. Each work's tacit propositions—that the well-tempered city is like a living body; that mechanized modernity imperils the Earth's homeostatic rhythms—are in no sense *proved* by these "visual tone poems."[1] Instead, these films convert an ensemble of biological concepts into a corresponding set of aesthetic forms—or, as I want to emphasize again in this Conclusion, into appropriately complex *ways of seeing*—giving the scientific knowledge of life an experiential dimension it would otherwise lack. If *Organism* takes up the well-traveled, metaphoric equation of cities and cells, and reformulates it as an *organismic vision*, then, by the same token, *Koyaanisqatsi* translates some of the core concerns of ecology into a repertoire of rhythms, patterns,

[1] Vladimir Zelevinsky, "Film Review: *Koyaanisqatsi*," *The Tech* 118, no. 68 (1999). http://tech.mit.edu/V118/N68/koyaan.68a.html.

propulsive movements, and uncanny synchronies—an experience that involves us in something like an *ecological perception*.

Considering *Koyaanisqatsi*'s status as a transitional episode in the popular circulation of time-lapse imagery, I want to assay, finally, how the lessons of *Unstill Life*'s historical case studies play out in the contemporary mediascape. Are the ideas, investments, and aesthetic categories explored in this study of purely historical interest, and do they apply only to variants of time-lapse photography? Have time-lapse techniques continued to evolve and flourish so that they occupy a distinctive and vital niche in today's media ecology? In one assessment of this last question, David Lavery suggests that the appeal of time-lapse imagery has largely waned as the technique has become more prevalent in commercial film and television.[2] As with other cinematic effects, he argues, its impact was strongest when it was still new and spectacularly strange. To some degree, as I have proposed in my discussion of Harris's experimental impulse, this condition of novelty can be recovered, however temporarily, through technical refinements and formal innovations. But Lavery's point is well taken that, as time-lapse displays become more commonplace, they seem to function predominantly as screensavers or transition shots—images that deflect attention rather than consolidate it. If one were to fill in this declensionist narrative, *Koyaanisqatsi* would play a major role—a film in which a range of time-lapse effects were integrated with cinematic language in an impressive and lasting way, reaching a wide enough audience to trigger a series of increasingly generic, increasingly vacuous citations. This passage from innovation to imitation is perhaps emblematized in Jesse England's parodic "found footage" film,

[2] David Lavery, "'No More Unexplored Countries': The Early Promise and Disappointing Career of Time-Lapse Photography," *Film Studies* 9 (2006): 1-8.

Koyaanistocksi (2016)—a shot-for-shot remake of an original trailer for *Koyaanisqatsi*, compiled entirely from watermarked stock footage.[3]

Yet despite this late, "disappointing career" (as Lavery calls it), there are several other ways in which time-lapse has continued to evolve, inform, and inspire. First, and in keeping with this dissertation's concern with experimentation, time-lapse techniques are still important tools for the contemporary sciences—e.g., in embryology, microbiology, botany, and astronomy—both in gathering data and in producing complex visualizations (where they are of course integrated with computer models and digital imaging technologies).[4] Second, on the other end of the visual-cultural spectrum, recent years have seen an unprecedented flourishing of *amateur* time-lapse videos, thanks to readily available software applications. These YouTube subgenres usher in new modes of "home movies" and family portraiture, marrying an obsessive interest in the plasticity of the human body to traditional forms of narrative affect—as in the bittersweet passage from infancy to adulthood, or the triumphal progress of a gender transition, or the regenerative circuit implied by the term of a pregnancy.[5] These examples remind us of the ethical stakes that have so often been imagined for time-lapse imagery—the technique's affinity for varied expressions and scales of "life." They likewise suggest that time-lapse can still navigate between the specialized enclaves of laboratory practice and the open spaces of vernacular, user-generated media effects.

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[3] Robinson Meyer, "*Koyannistocksi* [sic]: A Modern Classic, Recreated with Stock Footage," *The Atlantic*, April 8, 2016. https://www.theatlantic.com/technology/archive/2016/04/koyannistocksi-the-modern-classic-recreated-with-stock-footage/477543/

[4] See Janina Wellmann, "Animating Embryos: The *in toto* Representation of Life," *The British Journal for the History of Science* 50, no. 3 (2017): 521-35; and Scott Curtis, "Still/Moving: Digital Imaging and Medical Hermeneutics," in *Memory Bytes: History, Technology, and Digital Culture* (Durham, NC: Duke University Press, 2004), 218-254.

[5] Laura Horak, "Trans on YouTube: Intimacy, Visibility, Temporality," *Transgender Studies Quarterly* 1, no.4 (2014): 572-85; Jason Middleton, "Temporality and Pathos in Longitudinal Documentary," paper presented to Visible Evidence conference, Bloomington, IN, August 9, 2018.

But in weighing the timeliness of time-lapse photography, what sticks out, to me, is the question at the heart of *Koyaanisqatsi*'s critical reception: whether this, or any, technique can awaken us to imminent ecological realities. Asking this question means considering how scientific findings can be made palatable, and digestible, to a lay audience—but it also, most deeply, means teasing out the connections between seeing, thinking, and acting in response to environmental complexities. At one level, then, the legacy of *Koyaanisqatsi* has fed directly into more recent avatars of eco-activism, especially as environmentalist agendas have shifted from targeted conservation campaigns to raising a general alarm about the rising climate crisis. This timely fusion of media and politics is salient in the Extreme Ice Survey's adoption of time-lapse techniques to capture and convey the tangible realities of global warming—to wit, by taking serial photographs of ancient, globally dispersed glaciers as they melt, recede, and gradually disappear. Whereas James Inhofe infamously brandished a snowball on the floor of the United States Senate to symbolize his "doubts" about climate science, these time-lapse renderings of glacial erasure offer a counter-anecdote, one whose local effects illustrate in miniature the statistically well-documented story of our incrementally warming planet.[6] Cinematic renderings of rapid ice melts, as collected by the Extreme Ice Survey and included in the documentary *Chasing Ice* (Jeff Orlowski, 2012), intensify the visual rhetoric of "before and after" photos (long a mainstay of conservationist media tactics) by showing these processes as continuous and *ongoing* disasters. As a counterpart to this direct use of time-lapse photography, there are also visualization strategies that bypass photography while embracing a similar time-compressing logic to project the

[6] On the concerted media campaign to distort and weaponize "climate skepticism," see Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury, 2011).

possible impacts of climate change. One notable example comes in *An Inconvenient Truth* (Davis Guggenheim, 2006), where Al Gore's digital Earth presentation is occasionally animated to show how, as sea levels rise, coastal cities would be inundated in ways that redraw the world map.

These sorts of visualizations suggest that our ecological perplexities involve questions of complex temporality. Both folk wisdom and Western philosophy have made sense of our works and labors within finite, easily comprehensible timescales: the time it takes to sustain our lives, securing food and shelter, day by day; the time it takes to make and sell a commodity; the years over which we grow, mature, and form an identity; and the future generations to whom we offer a durable work of art.[7] When we represent the effects of climate change, on the other hand, the timescales involved are alien and unwieldy. The background data encompasses eons of chemical residues embedded in strata and in ice core samples; industrial emissions alter atmospheric concentrations of greenhouse gases in slowly accumulating increments; the human agents in question are not individuals, or communities, or even nation states, but are international in scope and stretch back decades; and the effects of environmental degradation lie, as a rule, far downstream from their original causes. In visualizing glacial melt, then, we begin to make some of this imperceptible agential circuit visible, bringing our senses into alignment with natural processes of vast dimensions. But it is well to remember that the phenomenon in question is one we are to understand as *un*natural, a product of anthropogenic impacts on the global environment, a thaw that is taking place before its time. We must appreciate the intervention of time-lapse photography,

[7] This perspective on the temporalities of work and labor is worked out in Hannah Arendt, *The Human Condition* (Chicago: The University of Chicago Press, 1958).

here, not as a correction of our defective senses, but as an imperfect interface between incompatible temporalities—an aesthetic register that does not resolve these layered asynchronies, but which makes them palpable in new ways. It becomes a way to image, and imagine, human activity's abrupt impact on natural bodies. It therefore alludes to other temporalities that are still not part of the picture. Even in these accelerated scenes, we are far from actually seeing the organic rhythms of glaciation, as they have played out over the course of environmental history.

This dynamic between what time-lapse literally shows, and what it only tentatively evokes, has been a persistent motif in *Unstill Life*. I am accordingly struck by a deeper kind of resonance between the nineteenth- and twentieth-century case studies that compose this dissertation, and the contemporary problematics of ecological thinking. In particular, they help us appreciate time-lapse techniques not just as "visualizing" some well-founded concept (like climate change), but as working up an idiom in which those concepts (like the temporal disjunction of climate cycles and anthropogenic impacts) become more wholly thinkable. Environmentally conceived films, in the mold of *Koyaanisqatsi*, can use time-lapse techniques to thematize the incongruence of natural and technical temporalities. The technique can also be used to generate rhythmic figures that complement a wider framework of visual analogies, a framework that proves highly germane to the ideal of ecological awareness. We are thereby confronted with a question: not whether we can see the totality of an ecological system, or of a way of life, but whether we can modify our senses so that we can see *ecologically*—see, that is, in a style that is attuned and measured to the diverse agencies that produce an ecology.

What is at stake in this ideal of pliable perception is one of the crucial themes to be derived from the preceding chapters. Chapter 1 tracked how seemingly ontological categories like indexicality, affinities, and revelation can be reframed as qualities of attention and investment—aspects of the phenomenology of photography. These categories help us understand the peculiar visual appeal of time-lapse photography: its power as an imprint, not a simulation, of natural movements; its capacity to enable new kinds of rhythmic and temporal analogies; and its impact as a marvelous revelation of unwitnessed qualities hidden in our most familiar surroundings. Time-lapse photography emerges, in this discourse, as a powerful example of Epstein's claim that cinema was not just a new art form or a new research tool, but was a "particular form of knowing."[8]

Time-lapse's altered ways of seeing, and how these were dialectically positioned between old and new forms of thinking, were also explored in the two middle chapters of this study. Chapter 2 was framed by a description of a hypothetical time-lapse display, depicting diverse expressions and scales of evolutionary transformation. This unrealized, precinematic "motion picture" signals the problematics of invisibility and illusion that have long shadowed theories of evolution—life's imponderably gradual processes of morphological transformation, and the seductive promise of recovering these transformations by filling in missing links in the fossil record. The same theoretical categories that specify the appeal of time-lapse displays inform the visual culture of nineteenth-century evolutionism: the temporal indexing of subterranean strata, the inductive reconstructions of extinct organisms, and the importance of recapitulation as a complex way of looking at life—one in which an

[8] Jean Epstein, "The Cinema Continues" (1930), in *French Film Theory and Criticism, A History/Anthology*, ed. Richard Abel (Princeton, NJ: Princeton University Press, 1988), 2.64. See discussion in Chapter 1.

embryo's course of development could be seen as a vivid reenactment of phylogenetic evolution. I explored a similar perceptual principle in Chapter 3, in particular the notion of *Anschauung*, which was explicitly invoked by Wilhelm Pfeffer in his time-lapse studies of plant movements. More generally, the chapter considered how the relationship between botanical life and the creative power of imagination were touched by examples of photography and time-lapse imagery. The ambiguous proposition that plants are intelligent can be rethought in terms of the aesthetics of these plant-growth films. The question is not necessarily whether the thoughtfulness of plants is proved by these images, but whether we are able to *recognize* certain forms of intelligence in beings where we would not otherwise have looked for it. In short, the kind of intelligence at stake simply *is* its recognizability—not an attribute belonging privately to plants or to us, but a way of accounting for the sympathetic relation *between* us and plants, which we perceive as a thoughtfulness common to their behaviors and ours.

These historically-situated chapters examine how time-lapse effects can be used to cast an altered eye upon nature, and how this dynamic iconography invigorates a broader language of visual analogies. In the case of classical film theorists, this texture of analogies informed understandings of the cinematic medium itself: just as a time-lapse image could confront its spectator with a plant's intelligent striving, so the cinematograph could be equated with a new "form of knowing"—an emergent philosophical paradigm, as Epstein saw it, in which static Enlightenment concepts and categories were thrown into disarray.[9] My attention to time-lapse imagery, as a peculiar subregion of cinema's revelatory effects, similarly insists on the connection between a newly dynamic way of seeing and

[9] Epstein, "The Cinema Continues," 64.

corresponding disturbances in our styles of thinking. These styles of thinking are often characterized by nonanthropocentric alliances and speculative affinities—as in the prominent case of botanical imagery—and an unsettling of epistemes, which I have associated with time-lapse's literal and thematic *unstilling* of worldly phenomena. Just as cinema took photography's static icons and restored them to living motion, so time-lapse imagery takes some seemingly settled element of our visual experience and "restores" it to its natural liveliness. The profilmic world is literally "sped up" in a time-lapse display, but the effect's phenomenology suggests something more—a view on life from a new angle, or through a new optic; an alteration of time that seemingly "corrects" our ordinary perception of things. A sense of layered asynchronies attends our appreciation of these icons, a reminder that our senses and faculties—and perhaps our concepts and our ways of life, too—are out-of-synch with the living realm's teeming processes, agencies, and energies.

These lessons about time-lapse effects, and their historical entanglements with adjacent media and various traditions of natural inquiry, shed light on our attempts to picture, cognize, and rework the unstable temporal horizons implied by the current climate crisis. This is how I understand the contested notion of the Anthropocene: a speculative projection of our historical present into the geologic record—a projection begged by the statistical realities of climate change and biodiversity loss, while also entailing a *future* perspective from which the present finds its inevitable inscription in uncovered strata.[10] There is a radical gesture in picturing our carboniferous economy as a slice in geologic time, an uncanny compression of industrial modernity reworked as a narrative of precipitous species

[10] J.R. McNeill and Peter Engelka, *The Great Acceleration: An Environmental History of the Anthropocene* (Oxford, MA: Belknap, 2014).

declines, temperature rises, and toxic residues—residues which reach into an imponderable future just as evolution conjured fugitive images of the "deep" past.[11] In short, our ethical responsibilities to present and future lifeforms now task us with becoming different sorts of temporal beings—capable of perceiving and reflecting in ways commensurate with the long-term consequences of our actions. The lessons that we need to learn—of adaptation and attunement; of connecting sight and thought along new axes; of projecting visible qualia into invisible forces and speculative analogies—these lessons are central to the genealogy of time-lapse effects and interactions I have sketched here. As in the example with which I introduced this project—the fictional flip book of a growing chestnut tree described in *The Overstory*—the question is how certain, time-condensing uses of a photographic medium can help us "think different about things."[12]

Of course, with the question of photography, it needs to be acknowledged that the possibility of seeing and thinking "different" depends on the character of the wider media environment. More than the withering of indexicality, what the transition from analog to digital media signifies is a shift in our ways of using and relating to (and through) our dominant media technologies. In fact, indexicality, though often treated as an ontological category, is a concept that implies and emblematizes a matrix of background beliefs—or what Peirce called our "collateral knowledge."[13] Our emotional susceptibility to a photograph depends on our beliefs about how it is formed, how that formation resembles the causation of footprints or fossils or photosynthesis, and how its likenesses require the participation of its subjects. Similarly, the full power of time-lapse imagery has, as *Unstill*

[11] Peter C. Van Wyck, *Signs of Danger: Waste, Trauma, and Nuclear Threat* (Minneapolis: University of Minnesota Press, 2005); On time-lapse vis-à-vis "deep time," see Chapter 2 of the present work.
[12] Richard Powers, *The Overstory* (New York: Norton, 2018), 19.
[13] See the discussion of this in chapter 1.

Life has explored, involved complex metaphorical ties to natural agencies, to our serial encounters with deep time, and to the suggestion that these moving images are not just simulations of unseen life but actual, vivid transcriptions of it. The technique's early and sporadically renewed poignancy combined the splendor of illusion with the authority of the photograph. But if photographic film and computer animation function as equivalent assets in today's digital image economy, and if our interactions with media now presuppose that photorealistic images are undetermined by physical laws and are endlessly revisable, then this earlier logic of revelation—this dialectic of visual intimacy and existential remoteness—may be a defunct aspiration.

Yet the epistemic implications of time-lapse techniques are germane to contemporary questions about visualization, especially imagery that is meant to circulate knowledge, and inspire care, among scientists and a lay public. I cannot shake the feeling that we stand to gain much by appreciating the narrow principle at the heart of early uses of time-lapse photography, and the logics implied by it—seeing the world's rhythms through a new lens, feeling their beauty, acknowledging their presence, and yet knowing ourselves to be existentially absent from them. These past configurations of vision, emotion, and knowledge are perhaps distant enough to seem alien to us now, hopefully in ways that inspire reflection. At the heart of this hypothetical openness to analogical thinking is the wager that these alternative modes of vision, with their distinctly embodied registers, continually task us with reworking the dimensions of our imaginations and the coordinates of our value systems. They ask us to ponder our relationship to the fabric of great externalities in whose midst we live and breathe, and this evokes the flavor of our current predicament. The best visualizations don't provide us with new knowledge readymade, but rather help us realize

that we have more thinking to do, and equip us with materials to work over in our imaginations.

So even if the poetry of time-lapse has become increasingly prosaic, the *ideas* implied by time-lapse photography, in its coordination of technical apparatus and marvelous imagery, remain relevant and illuminating. Thinking about the lifespan of time-lapse photography helps us think about how other visual protocols *might* still strive to play on our background beliefs in ways that dazzle us, provoke us into new ways of beholding our manifold environments, new ways of thinking in our ecological catastrophe, new cues to acting inventively. Perhaps there is still some inspiration to take from the spectacle of a confidently growing plant, and from our undiminished capacity to bear witness to, and take pleasure in, this endlessly generative intelligence.

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