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"Stutter-Stop Flash-Bulb Strange": GMOs and the Aesthetics of Scale in Paolo Bacigalupi's *The Windup Girl*

The opening scene of Paolo Bacigalupi's novel *The Windup Girl* (2009) takes place in a bustling market in a distant-future Bangkok, where the American Anderson Lake encounters a new fruit. "The fruit's long hairs tickle his palm [and the vendor's] brown thumb easily tears away the hairy rind, revealing a pale core. Translucent and veinous, it resembles … the pickled onions served in martinis…. Anderson sniffs tentatively. Inhales floral syrup. [It's called] *Ngaw*. It shouldn't exist. Yesterday, it didn't" (2). The passage underscores a deep-running representational problem for an sf novel that is centrally concerned with genetic modification. Genetically modified organisms (GMOs), as they exist now, are often aesthetically pleasing, if they are visible *as* GMOs at all. That invisibility has recently been at the center of recent GMO labeling debates over whether consumers in grocery stores should be informed of the GM status of produce. California's Proposition 37 in fall 2012 raised the issue as a prospective state law, but the motion did not pass; the national grocery chain Whole Foods announced in the spring of 2013 that they would label GMOs within the coming five years.[1] The fruit that Anderson encounters in the Bangkok market sounds exotic and delicious—it is a rambutan, brought back from a future extinction—but the main sign of its genetic modification is its apparent immunity to the plant diseases that have decimated global agriculture in the novel. The fruit is a beacon of aesthetic pleasure and rebirth in the otherwise bleak and barren future that Bacigalupi imagines in *The Windup Girl*. In a future without fossil fuels, an American corporation (AgriGen, a fictional version of GMO producers such as Monsanto and Pioneer Hi-Bred) wields global influence over farming practices, and a class of its "gene rippers" create new fruit, new species, and general chaos.[2]

This novel's opening scene lays out an aesthetic problem that persists throughout the work and through much fiction, scholarship, and activism surrounding GMOs. Here, the immediacy of the aesthetic experience of the fruit itself is lushly foregrounded, while the DNA molecules that have been hacked to produce the fruit are of course far too small to be seen with the naked eye, and the information they contain is too abstract to be immediately understood. When Bacigalupi takes genetic modification as the subject of his work, he encounters the difficulty of mediating between incommensurable scales. In attending to the GMO's possible invisibility, the novel makes a strong case for fiction's usefulness in rescaling and remediating techno-scientific issues such as genetic modification.

Bacigalupi's novel approaches the concept of scale in several modalities at once, not least because the genome is spatially minute parallel to the way in which a post-oil future, the novel's setting, is temporally distant. The novel

thus addresses spatially microscopic phenomena and ecological scales of temporal duration, as well as questions about human agency in relation to these very large and very small processes. The novel focuses on questions about scale that have been raised in recent work by Rob Nixon, Dipesh Chakrabarty, Wai Chee Dimock, and Mark McGurl. Those other works have emphasized the representational challenges confronting an array of contemporary environmental and technoscientific issues, from the rising sea level to viral contagion, as well as the question of humans' geological agency as posed in theories of the anthropocene. Particularly when important changes take place at a remove from the visceral impact—and at nonhuman scales such as the molecular in space or the ecological in time—the narrative and aesthetic dimensions of activism face new challenges.[3] In a recent exchange with Dimock in *Critical Inquiry*, McGurl suggests, "all literature tries to be … a kind of scaling device, scaling up and scaling down as needed in furtherance of the will to live" (634). While McGurl writes in reference to the cosmic indifference of H.P. Lovecraft's work, the notion that literature might be able to scale the world's inaccessible phenomena up or down in order to meet the human observer and reader remains a powerful one. As a writer, Bacigalupi also spends time writing activist journalism for environmentalist causes, and perhaps as a result his fiction writing is particularly attuned to the ways that fictional form might develop to address problems of technoscientific scale.

Much of *The Windup Girl*'s resourcefulness in translating scales comes from its borrowing from other media forms: video games, CGI special effects, and particularly the cinematic trope of the automaton. I characterize these borrowings, and consequently much of the novel's aesthetic work, as forms of *remediation*. Jay Bolter and Richard Grusin have described the coexistence and merging of media forms with each other through a "double logic" of remediation: a proliferation of distinct media forms ("hypermediacy") often appears within texts whose goal is to convey pure or unrestricted access to experience ("immediacy") (313). In addition to setting the concepts of genetic modification and environmental disaster into narrative motion, Bacigalupi's novel brings genetic programming to bear on a human scale by borrowing from other media. While the consumption and incorporation of other media, such as letters, poems, and dispatches, has always been a hallmark of the novel as a form, *The Windup Girl* draws particularly heavily on visual media. In so doing, it also brings about the convergence of two significant sf subgenres: first, the novel of genetic modification, in which *The Windup Girl* is one of the more fully realized exemplars; and second, the sf of human programming, a subgenre comprised of films, novels, and stories that imagine techniques for programming the behavior and movement of humans or humanoid characters.

In what follows, I will discuss how *The Windup Girl* intervenes in both of those sf subgenres by foregrounding problems of scale. First, it diverges from most conventional fictions about genetic modification by moving beyond an aesthetics of disgust vis-à-vis products deemed to be unnatural. As with the rambutan in the novel's opening, the invisibility of the GMOs' genes renders

impotent any aesthetic appeals to the "natural." The novel's primary gesture of remediation, discussed in this article's second section, is to relate the gene to the temporalities of programming and agency—of visible causes and effects—in a set of "programming" images and temporalities borrowed from visual media. The scenes of remediated programming in the novel consistently emphasize the importance of shifting scalar perspectives, in both time and space, when we are looking to distinguish between coerced and freely chosen acts, or between mechanism and agency. Lastly, the novel's ending also relates the gene to its deep temporality in terms of species time, which I relate to the importance of shifting scalar perspectives as a methodology for reading.

Scale and the Aesthetics of GMOs. By virtue of its setting in the distant future, *The Windup Girl* already deals with one facet of temporal scale that has long been a signal strength of sf: it depicts the sorts of change that cannot occur within a single human lifespan in the present. In Isaac Asimov's FOUNDATION novels (1942-93), for instance, the scope of social-scientific expertise and planning, or "psycho-history," dictates that a variety of characters stand in as psycho-history's functionaries across a span of thousands of years. Likewise, the inclusion of characters with unusually long lifespans, as in Octavia Butler's PATTERNIST series (1976-84), can be a common strategy for watching *longue durée* events unfold in sf. *The Windup Girl* turns its attention to many different political issues involving scale, and the issues of peak oil and climate change are brought to the fore by the novel's setting in the future. The novel refers to the historical present as "the expansion," a time when energy expenditures and oil consumption ran wild and little was done to stop climate change on a global level. Global corporations in the novel including AgriGen dominate the world economy through their control over GMO technology and the food supply. Against this backdrop, *The Windup Girl* recounts a particularly complex plot: Anderson Lake, a spy for AgriGen, seeks out Gibbons, a rogue geneticist, and the Thai government's seed bank, a valuable source of genetic data for his company. In the course of these investigations, Anderson falls in love with Emiko, a "New Person," a member of a genetically modified slave class from Japan, who is also a sex worker who has the Somdet Chaopraya, or king regent, as a client. Against Anderson, the novel introduces a crusader for the Thai Ministry of the Environment, Jaidee Rojjanasukchai, and several other characters, for all of whom daily life in a post-oil state of energy scarcity is difficult. In addition to performing the function that Fredric Jameson has identified as sf's ability to the "present as (past) history"—allowing us to see our current moment as the proverbial owl of Minerva—*The Windup Girl*'s setting makes visible a new perspective on our present and the distributed agency in the twentieth and twenty-first centuries that brings this possible future into being (296). It is the world organization of our time in general—oil corporations and lobbyists, certainly, but also ordinary consumers, more and less powerful government officials, and even established trade patterns and methods of energy storage—that is "responsible" for the future crisis. The distance of history here, by no means atypical of the

best sf, allows us to see the complexity of social process from a manageable distance, in order to convince the reader that sweeping, perhaps unfathomable, changes in our society will be necessary to prevent future environmental collapse. Along these lines, Andrew Hageman has discussed the novel in terms of its remarkably thoughtful political setting and its inventiveness in imagining an ecological future through that setting, noting that this imagined future helps readers to "disassemble" "the concepts of 'Nature,' the 'human being,' and ecologically sustainable capitalism" (284).

While the part of of Bacigalupi's novel that deals with energy consumption works in an effective but not unusual way with large scales, *The Windup Girl* approaches the small-scale aspects of genetic modification in a way that is distinct from the aesthetics of disgust that characterizes many fictions that address the topic. The DNA molecule is infinitesimally small, and the processes of synthesizing and folding the proteins it creates are chemically and physically complex. It is difficult even with magnification to make visible the effects of RNA synthesis. Where fictional narrative techniques such as distant-future settings or immortal characters have proven useful for conceiving of large-scale temporal issues, small spatial scales more readily suggest magnification or a focus on the media of viewing. The infinitesimally small can, of course, be zoomed into in film and in other visual media: Charles and Ray Eames's educational film *Powers of Ten* (1977) still stands as perhaps the best demonstration of the educational potential of composite zooming. As a couple lies on the grass in a park, camera zoom is combined with photo and illustration compositing to show both the outer reaches of space and the inner spaces within atoms. Ridley Scott's *Prometheus* (2012) incorporates a similar zoom into its narrative about DNA; its opening sequence features the bursting-apart of a DNA molecule and makes use of a CGI zoom effect to show the effects of a poison that corrupts this molecular basis of cell reproduction. Because the cells in our bodies carry life spans of months or years, the immediate implosion of the humanoid body at the beginning of *Prometheus* takes liberties with timing. We see the DNA rip apart at the microscopic scale, and then the body instantaneously disintegrates back on the human scale. *Prometheus* represents the effects of this genetic poison as being much like the chain reaction that takes a nuclear explosion beyond critical mass, but in fact DNA's effects occur much more slowly, with the growth and reproduction of cells. And yet this DNA explosion provides the shorthand for representing the power of that film's Engineer characters, who can manipulate the DNA molecule and thereby wield a god-like power over life itself. Because the genome carries a certain mystique even after having been fully "mapped," its effects are often represented as the small-scale control over life itself, but within more and less realistic representational schemes.

Because of this representational difficulty, genetic modification is most often made visible in artwork and literature through the expression of extraordinary and unnatural-seeming traits.[4] Eduardo Kac's "GFP Bunny" (2000) made use of genetic modification techniques to create a transgenic rabbit that possessed the green fluorescent protein (GFP) that is responsible for

the bioluminescence of the jellyfish *Aequorea victoria*. Kac described "GFP Bunny," one of the foundational works of "bioart," not just in terms of the rabbit itself, but also as a "complex social event [around] the creation of a chimerical animal that does not exist in nature" (97). By creating a chimerical creature using transgenic techniques, the artwork addressed popular understandings of the "natural" and the "chimerical." Likewise, Margaret Atwood's *MaddAddam* trilogy (2004–2013) makes use of chimerical and grotesque figures, including rabbit-skunk hybrids, the blue humanoid "children of Crake," and the protean, brainless "ChickieNobs" (204), as the offenses to "Nature … with a capital N" that animate discussions between its protagonists (206). The aesthetics of disgust or freakishness to which chimerical creations often appeal draw the reader's attention to the ways in which we define or sense the boundary between the natural and the unnatural.[5] The disgusting or the chimerical offends the viewer's sense of taste, as when the protagonist of Atwood's *Oryx and Crake* (2004) "couldn't see [himself] eating a ChickieNob. It would be like eating a large wart … or maybe he wouldn't be able to tell the difference" (203). Even with this chimerical creation, the final product in this depiction aims to have its differences from the ordinary escape the consumer's notice. The ChickieNob's DNA is different, so the production processes are different, but on the plate it appears the same. As with Marx's commodity, wherein the surface of the product we see occludes the labor relations that went into its manufacture, the GMO can appear on a plate or in a grocery store without betraying its origins.

In the world of *The Windup Girl*, there are several chimeras, but few end-product organisms are at all noteworthy as "genehacks," even though the novel's world is said to be replete with them. The novel's Christian "Grahamites" (presumably a reference to the twentieth-century father-son pair of US-based evangelists) flesh out the valorization of the "natural" that has often accompanied criticisms of GMOs to such an extent that the novel seems determined to render it obsolete. The Grahamites stay "focused on their Noah's ark, after the flood has already happened" (114), that is, in a position that is out of step with the present, in both our time and the novel's. With frequent reference to Eden and the Biblical flood, the Grahamites' desire to reclaim the natural becomes tantamount to a desire for time travel or global annihilation, since these are the only solutions for returning the world to a state of natural purity. By positioning the Grahamites as figures of ridicule in the novel, Bacigalupi shifts the terms of the argument about GMOs from appeals to the natural to appeals to ethics and scalar imagination, a shift he will accomplish through the figure of the windup girl. The Grahamites' search for the genetically natural is deftly called into question in the novel, in much the same way that critics have called the category of the natural into question in discourse surrounding GMOs. Jill Didur, for instance, has shown how Monsanto's publicity literature has stressed the continuity between breeding techniques considered to be "natural" and their own supposedly "unnatural" techniques. In the 1990s Monsanto adopted a sophisticated rhetorical strategy to warm up farmers and the public to their products. Because farmers have

bred plants through selective breeding techniques and hybridization "for centuries," Monsanto's genetic engineering can be seen as a logical "extension" of farming techniques, which transfers the same kinds of "genetic information in a more precise, controlled manner" (qtd. in Didur, 104, 105). When Monsanto can align their products with ordinary farming techniques, it becomes clear that the contestable category of the natural cannot form the bedrock for resistance to GMOs.

This representational difficulty applies in the activist realm as well. The disgust that might motivate Kac's audiences or Atwood's characters to worry about GMOs can be difficult to conjure relative to the ordinary-seeming GMOs that surround us. As of July 2014, the first transgenic fish, the AquAdvantage Salmon (AAS), is nearing FDA approval, and it is exemplary in being undetectable as a GMO to the end-consumer. Its colloquial name "Frankenfish" connotes the chimerical and unnatural by appealing to Mary Shelley's monster, but this particular caricature misses its mark. According to maker AquaBounty's promotional materials, AAS "grow to market size in half the time of conventional salmon" and are "grown as sterile, all-female populations" to prevent population escape or overrun. The AAS is not even, like Atwood's ChickieNob, disgusting when we see the fish itself; it simply grows more quickly. The genetic modification works on the animal's life cycle and metabolism, rather than as the metaphorical stitching-together of mismatched parts. Like the insect-resistant and herbicide-tolerant crops that constitute the bulk of GMOs currently, AquaBounty's salmon is simply programmed to interact with its environment in a different way.[6] In a recent special section of *Nature*, authors pointed to a new wave of GM research that focuses on increasing the nutritional content of staple foods, such as rice and bananas, in the developing world. At present, however, "the market is dominated by just a few insect-resistant and herbicide-tolerant crops," whose effects on the plants cannot be seen by the naked eye ("Plant Biotechnology: A Tarnished Promise" 21). In one exceptional work of bioart described by Robert Mitchell, *Free Range Grains*, artists Beatriz da Costa, Shyh-shiun Shyu, and the Critical Art Ensemble invite audiences to test ordinary foods from the grocery store for genetic modification, an explicit nod to the invisibility of most GMOs (24, 64).

Accordingly, *The Windup Girl* focuses most on the sociopolitical dimensions of genetic modification: population overrun, the ownership of genetic information, programmed traits such as infertility, and the jurisdictions of regulation, quarantine, and importation. The most prominent chimera of the novel, the "cheshire," is remarkable for teaching the gene hackers several important "lessons," after this species of particularly stealthy cats have decimated domestic cat and wild bird populations all over the world (114). These cats, "flicker-shimmer shapes" that recall Lewis Carroll's *Alice in Wonderland*, had been created without regard for their potential effect on the global ecosystem (7). This takeover informs the design of the New People, or windups, a servant class of genetically modified humans. Taking this "lesson" from the cheshire cats, they are bred to be both infertile and obedient to their

masters (113). Emiko, the novel's primary windup, observes that, as an infertile woman, she too is a "genetic dead end … doomed to a single life cycle, just like SoyPRO and TotalNutrient Wheat" (113). By making this shared fate a point of commensurability between Emiko and GMO seeds, Bacigalupi's novel disagrees with thinkers such as Francis Fukuyama who rigidly demarcate human genetic modification from plant GMOs, as Hageman has noted (293). Even though Emiko dreams of escaping to the rumored enclave of runaway windups in the rural North, infertility places a biological limit on the flourishing, and the future, of such a community. The explicit comparison between agricultural terminator seeds and Emiko's human future draws our attention to how the seed companies' self-interest acts to the detriment of conventional plant and human life cycles. This infertility stands as a consequential—but once more an invisible—trait programmed by genetic modification.

The genetic modification in the novel is, then, realistically invisible to the naked eye, though its practical consequences are felt everywhere in this future scenario. In this regard, the novel's primary intrigue involves American corporations'—and particularly Anderson Lake's—attempts to break into the Thai government's seed bank. In the novel's account of the fall of Jaidee Rojjanasukchai, the last incorruptible official in the Thai Ministry of the Environment, Bacigalupi allegorizes the ascent of transnational corporations on the world stage of power, as well as the concomitant fall of the nation-state. This fall is set up at the outset of the novel, where "the Thai Kingdom" is extolled as "clever where others are not. It thrives while countries like India and Burma and Vietnam all fall like dominoes, starving and begging for the scientific advances of the calorie monopolies" (3). By the novel's end, Thailand, too, falls. The novel's main plot examines GM technologies' effects on socio-political scales, eventually including state regulatory practices (and the forms of their powerlessness against transnational corporations), disease outbreak, genetically programmed immunity, and struggles for control over the information contained within specific plant genomes. In the scope of this political intrigue, *The Windup Girl* shares much in common with Ruth Ozeki's novel, *All Over Creation* (2003). Ozeki's novel explores in detail the political ramifications of the Cynaco corporation's introduction of GM potatoes into an Idaho farming community, a plot that closely follows Monsanto's introduction and recall of a similar potato. The representational challenges of that novel lead the critic Susan McHugh to ask, "why do animals (and not plants) loom large in the transgenic imaginary while plants … have become the medium of daily encounters with transgenic organisms?" (25). Such plants—especially a lowly potato whose transgenic property is a pesticide—lack the drama that is intrinsic to human and even animal actors. In a turn toward sf techniques, Bacigalupi's novel addresses precisely that problem.

Genetic Programming, Remediated. The scales at which GMOs matter most—in the inner workings of cells and in the *longue durée* of ecological time—are decidedly difficult to relate to in terms of individual human agency,

so Bacigalupi turns to the repertoire of effects that sf has developed for other representational concerns. Istvan Csicsery-Ronay, Jr.'s account of that repertoire, *The Seven Beauties of Science Fiction* (2008), usefully relates the science-fictional sublime—a natural choice for thinking about scale—with a unique understanding of the grotesque within sf. In the Kantian understanding of the sublime, a phenomenon appears to the viewer as infinitely large (or infinitely powerful), so that the faculty of imagination outstrips understanding.[7] Csicery-Ronay, Jr., takes that destabilizing effect of the astoundingly large and powerful things created by sf science and finds its mirror image in the grotesque, which destabilizes our fixed categories by setting them at odds with each other *within* a discrete object. Where "the technosublime is *extensive*, inducing sentiments of awe and dread in response to phenomena either created or revealed by human techniques," the opposite tendency of "the grotesque is *implosive*, accompanied by fascination and horror at the prospect of intimate category-violating phenomena discovered by science" (7; emphasis added). Such an understanding of the grotesque encompasses chimerical GMOs, certainly, but it also describes Bacigalupi's method of drawing attention to various scales of mechanical process in the body through the novel's central figure of Emiko, the windup girl. The conceptual difficulty of considering the body both on a cellular level and on an intersubjective one activates the same conceptual confusion Csicsery-Ronay associates with the sf grotesque, which

> turns the arrested attention intensely toward things, in which it detects a constant metamorphic flux, an intimate roiling of living processes that perpetually change before understanding can stabilize them. This process is one of steady descent into interiors, into grottoes of being, in the hope of finding a core, but always finding more transformation. (190)

The Windup Girl importantly accomplishes this effect through the display, not of physical mutation, but of unusual qualities and temporalities of movement, a direct borrowing from the cinematic convention of human programming.[8] The novel attempts to remediate the representational problems associated with genetic modification by manipulating time.

The programmed person, or human automaton, has been one of the most ubiquitous sf techniques of the cinema because it is also one of the simplest and least expensive. Actors move as though they are mechanical or as though they have been hypnotized, brainwashed, or programmed. In many cases, this movement makes a visual comparison to mechanical dolls or automata, whose "windup" mechanisms drive their movement. Surprisingly, this effect of simulated will-less motion has been a central feature of both avant-garde masterpieces and the worst B-movies, from the early cinema of attractions to *Prometheus* and *Upstream Color* (2013). Consider the jerky movements of the robotic Maria in *Metropolis* (1927), Chaplin's tramp at the circus or in the factory, the halting movements of *The Manchurian Candidate* (1962), the uncanny spasms of the android Ash in Ridley Scott's *Alien* (1979), and the replicants' speedy movements and jittering malfunctions in *Blade Runner* (1982). Automatic movement has been a profound source of both comedic and

uncanny effects in cinema, one that takes the cinema's primary subject, the human form, as the object of a skeptical or fascinated gaze. In Henri Bergson's analysis of mechanical motion, for instance, our mechanicity signals a momentary loss of vitality and adaptability; bodily motion that seems not to obey conscious control likewise links to Sigmund Freud's and Ernst Jentsch's well-known analyses of the uncanny. This aesthetic form arrests our gaze in the service of considering the nonhuman motors within the human, an effect *The Windup Girl* uses frequently.

Moreover, the windup's namesake trait of automaton-like motion actively revises the aesthetic traditions of sf in order to bring them into conversation with GMOs. Emiko's movement is introduced in prose that recalls the lushness of Anderson's rambutan in the novel's opening scene:

> As soft as skin can be, and perhaps more so, because even if her physical movements are all stutter-stop flash-bulb strange, her skin is more than perfect. Even with her augmented vision she barely spies the pores of her flesh. So small. So delicate. So optimal. But made for Nippon and a rich man's climate control, not for here. Here, she is too hot and sweats too little. (35)[9]

Here, Emiko sees herself as the object of an orientalist male gaze that fixes on the special effect of her movement. The flash-bulb suggests the intermittent visibility of the subject under strobe lighting, while the concomitant "stutter-stop" motion refers us to the aesthetic conventions of automaton motion in cinema. The passage emphasizes Emiko's enhanced vision and also that which escapes it: she cannot see the features of the poorly designed skin that makes her overheat, much less the DNA that is its cause. In the final sentence of the above description, in a turn toward Emiko's own experience of the hot climate, the narration shifts the reader's gaze away from that orientalist perspective and toward a sympathetic moment with Emiko, whose discomfort in Thailand is a recurring motif. The novel's interest in sight includes, then, an alternation between a magnifying gaze that might discern the molecular machines that drive organisms and the intersubjective gaze through which empathetic acknowledgment might take place.

In its aesthetic effects, *The Windup Girl* weds the effects of genetic modification to a logic of programmability, a logic that has been applied to humans and to computers in popular texts over the past half-century. As a horizon of scientific possibility, the novel treats genetics like a program that might allow or compel the body to do anything that a computer program might allow a computer to do. Wendy Chun has recently suggested that contemporary technologies from genetics to software encourage this "logic of programmability" that circulates between disparate domains of contemporary cultural production (9). That logic, Chun suggests, "is not limited to computer technology; it also stems from and bleeds elsewhere, in particular modern genetics, with its conceptualization of codes and of programs as central to inheritance" (9). Lily Kay's comprehensive study, *Who Wrote the Book of Life?* (2000), charts how a logic of programmability evolved through the historical exchanges between cybernetics and molecular biology in the 1940s,

when the concepts of the gene as an informatic "code" and the concept of the computer program emerged in a complex feedback loop with one another. Kay has traced the ways that cybernetics, which would form the basis for computer research and development, inspired many of the approaches of genetics research. The new orientations toward communication and coding that had been enabled by cybernetics sparked a chain of research in biology by Henry Quastler, George Gamow, Alexander Rich, James Watson, Francis Crick, and Leslie Orgel, among others, that led to the full description of the genome as a code (Kay 115–92). Moreover, the biologists who also popularized the idea of DNA, including François Jacob and Jacques Monod, frequently explained the concept of DNA synthesis through the metaphors of cybernetics, speaking of heredity as "the memory of a computer," of molecules' "communication network[s]," and DNA's "electronic automation circuitry" (Kay 17). "From the 1950s on," in Kay's narrative, "the diachronic resonances of the Book of Life as transcendent writing were amplified by the synchronic articulations of DNA as a programmed text, and information became the animating *Primum Mobile*. The genetic code became the site of life's command and control" (5). That shift in thinking, enabled by cybernetics, allows us to imagine the human body as information all the way down. In much the same way that what David Golumbia has identified as "computationalism" in cognitive science and other domains has catalyzed thinking of the mind as a computer, genetics and the logic of programmability have produced an understanding of life as programmable at the molecular and cellular levels.[10]

Because the word "program" derives from the Latin for "writing forth" or "writing in advance," a complex temporal logic governs the notion of the genetic program. In some senses, as with certain genetic diseases or the accelerated growth rate of AAS transgenic fish, genetics can describe the contours, at least, of one's life. Priscilla Wald considers the grammatical "future perfect" for genomics, in which the predictability of gene expression allows us to "look forward as though looking back" (698). Because knowledge of the gene resembles knowledge of the future, Wald continues, many entertain "the possibility (often disclaimed) that geneticists will be able to alter their perspective on human fate, to transform time, in effect, such that the perspective on the future resembles our current perspective on the past" (698). In such a scenario, only expertise in genetics can change the program, and then only for future generations.[11] A figure such as Emiko finds herself wholly out of control of the expression of her genes, a pivotal point for the end of *The Windup Girl*, to which I will return.

This metaphor of genetics as programming applies also to the temporal present, positing that a tiny, nonhuman agent is at work within our bodies, controlling aspects of our lives that are beyond our control. While reflexes or the unconscious have often occupied this role in sf and in scientific imaginations, too, the gene constitutes human programming on a distinct spatial scale from those based in scientific paradigms of behaviorism. The behaviorist paradigm of conditioning and training precedes both the discovery of the gene and the notion of computer programming, and had been

widespread in US culture by the time of the introduction of genetic programming. Many mid-twentieth-century narratives of human programming, such as *1984* (1949), *A Clockwork Orange* (1962), and *The Manchurian Candidate* (1962) imagined variations on behaviorist conditioning, such as brainwashing, torture, and extreme forms of discipline, in the most common and familiar version of the programmed subject. In casting genetic modification within the tradition of human programming in the cinema and fiction, *The Windup Girl* combines the programming attributed to a future genetic science with more conventional behaviorist conditioning. Accordingly, descriptions of Emiko also emphasize various regimes of "training" she has been through in addition to the genetic programming that impairs her bodily movement. Early in the novel, she mentions that she once had "the stylized grace that her mistress Mizumi-sensei trained into her when she was a girl in the crèche" (37). This training—with the invasive connotation of "training into"—adds "elegance" and "care" to Emiko's strange movements, and it recalls the movements of a geisha or consort, or even the many years of training that bunraku puppeteers undergo in order to make their puppets graceful and lifelike. She has undergone intensive behavioral training in order to become a windup consort, which instills obedience and gives her "the careful steps of a fine courtesan, stylized and deliberate movements, refined over decades to accommodate her genetic heritage, to emphasize her beauty and her difference" (36). Curiously, then, Emiko requires training that supplements her genetically ingrained behavior.

With this addition to her back-story, Emiko's behavior, desires, and instincts are accordingly suspended between genetic explanations and behaviorist explanations throughout the novel. This split separates habits that might be changed with more deeply ingrained traits that cannot be changed, making of them two scales of possible control. That uncertainty between genetic programming and behaviorist conditioning plays out as one contemporary version of the distinction between nature and nurture. In one scene written from Anderson's perspective, Emiko says, "'My body is not mine … the men who designed me, they make me do things I cannot control. As if their hands are inside me. Like a puppet, yes?'" (183). In this image, Emiko attempts to explain her behavior as the distended will of her—always male—creators, a metaphor literalized in her puppet-like motion. Upon hearing this description, Anderson sifts through more metaphors in order to attempt to understand her. He imagines after some time "her soul, emerging from within the strangling strands of her engineered DNA," a "soul that wars with itself" (183). This arresting image startles through its scalar incongruity, as though the soul—conceived as that which is not programmed by genetics—might be at the same time the whole person he deals with and a microscopic unknown in the middle of a cell. Anderson conceives of the "war" within Emiko as one that occurs among this "soul," "some portion of canine DNA" that ensures her loyalty, and "the training that she has spoken of" (183–4). The closely examined "war" within Emiko corresponds neatly to Csicsery-Ronay, Jr.'s description of the grotesque as a "hope of finding a

core" to a being whose workings are unclear (190). Moreover, the secular "soul" the novel mentions on numerous occasions tends to amount only to the portion of Emiko's consciousness that cannot be directly accounted for through scientific knowledge. Even Gibbons, the gene ripper she encounters in the epilogue, mentions the genetics and the training simultaneously: "'I have read about your kind.... About your genetics. Your training.... Stand up!' he barks. Emiko is standing before she knows it. Standing and shaking with fear and the urge to obey" (357). This uncertainty locates Emiko's humanity in the possibility of free action—if her every action has been coerced or programmed, then she truly is subhuman. Such a depiction of unfreedom hearkens back to films such as *The Manchurian Candidate*, where characters and viewers wonder whether the sleeper agent Raymond Shaw is acting under his own volition. Within the brainwashing subgenre, as David Seed has pointed out, narrative tension is often built around a flaw in the brainwashing mechanism, or incomplete brainwashing (57). In *The Windup Girl*, the uncertainty surrounding Emiko's agency is suspended between her interpersonal interactions and two distinct paradigms—and scales—of human programming. The split prompts a question about genetics as programmed: if all forms of life are literally programmed (written in advance) by DNA, at what subjective level could that determination feel like programming?

Despite this subjective uncertainty about the sources and scopes of human programming, that fact of programming becomes in *The Windup Girl* a mode of exclusion. If, as Kay describes the ideas surrounding genes, the gene is the site of life's "communication and control," then to consider a being as solely an expression of its genes is to consider it as essentially mechanical, that is, as a thing. In a recent overview, Jay Clayton has found in the several "waves" of fiction about human genetics since the 1950s a "typical plot form" that stages "the persecution of the emerging minority species by a terrified majority, the soon-to-be extinct Homo sapiens" (321). Bacigalupi's novel follows that convention, but it does so by suggesting that seeing others as large collections of microscopic genes is one way to see them as mere objects.

The novel considers the dynamics of exclusion through scenes of dehumanization, which again focus on ways of looking at the body. An early torture scene in the novel features Emiko in a live sex show, where her odd movement is featured prominently. Her tormentor, Kannika, "draws cries and moans" from her as a "novelty" for the audience, to whom she cries, "*Look! She is almost human!*"(34; emphases in original). The crowd does not take her pain seriously but finds Emiko's "stutter-stop motions" to be "a joke," an "alien toy" (36). While the reader likely finds this scene horrifying, the callous audience within the novel seems to find it titillating and exotic, or even humorous, as the word "joke" suggests. One man approaches and "stares intently, as if he is examining an insect under a magnifying glass: fascinated, but also repulsed" (36). Although the simile of a magnifying glass does not suggest that the man might literally see the genes that have programmed Emiko's motion, the image invokes a gaze that is intent on seeing the mechanical processes and articulations that make a thing function. Through

this variety of encounters, the novel emphasizes her reduction to an object, whether insect or toy, that the audience assumes cannot feel true pain or be worthy of sympathy. When Kannika pours beer over her that gets into her lungs, she becomes "nothing but a silly marionette creature now, all stutter-stop motion—herky-jerky *heechy-keechy*" (37; emphases in original). This movement apparently licenses the depraved audience to label her torture comical, "silly," and inconsequential. In depicting such a depraved audience, Bacigalupi's work participates in an aesthetics of disgust, but with a key difference from what is usually encountered with chimerical GMOs: instead of the organism itself provoking disgust, the audience stages a way of looking at another creature, and a larger network of exploitative interactions, that we find disgusting.

In its reversal of this objectifying, microscope gaze upon Emiko, *The Windup Girl* turns once again to the manipulation of time and movement in visual media. In perhaps the novel's most fanciful turn, a superpower allows Emiko to move from an explicitly subhuman being to an implicitly superhuman being by way of a shift in how she sees time passing. The genetically modified woman finds that at moments of crisis she is suddenly able to perceive things and move much more quickly than others around her: in her own perception, she moves at her ordinary speed, while everyone else moves in slow motion. During a chase scene, this new mode of perception overtakes Emiko without her knowledge: she watches her pursuers, "puzzled. They are halfway across the roof, but they are so very very slow. They seem to be running through rice porridge. Their every motion drags. So slow" (199). This increase in speed borrows not only from the cinematic technique of slow motion, which has been in wide use since the 1960s, but also from the late-1990s CGI effects of films such as *Dark City* (1998) and *The Matrix* (1999). Both of these films imagine ways for their protagonists to perceive at superhuman speed, as though these characters alone were computers running on more advanced operating systems than those around them.[12]

Although the guns in Bacigalupi's novel are different, spitting disks, bullets remain the gold standard of speed, which Emiko sees in a slow motion suggested by ellipses: "Their guns glint red. Disks spit toward her. One, two, three… she counts them as they fly… four, five" (199). Emiko's motion and perception are much faster than other humans', and this fact allows her to take revenge on her tormentors in the novel in a pivotal plot point. It is noteworthy here that Bacigalupi's image for the future of perception—the way of seeing the world that might be made possible by the genetics advances three centuries in the future—is borrowed from contemporary special effects and video-game technology, in the guise of Emiko's "bullet time." Indeed, far more than any current avenue of genetics research, the figure of Emiko draws on computational metaphors and the conventions of film special effects and video games, horizons of "cool" representation that capture readers' and film producers' imaginations.[13]

These computer-driven media, however, give readers a vivid way of imagining how to see microscopic amounts of time in otherwise unimaginably

great detail. When Emiko sees others in slow motion, it is those around her whose movements are suddenly predictable, as hers had seemed to be before. The novel makes use of this flipped perspective in the resolution of the plot at its personal and political levels: despite Emiko's sensations of, and others' assumptions about, her subjective unfreedom, her actions still have wide-ranging effects and consequences. *The Windup Girl* cleverly stages Emiko's revenge near the novel's climax, in which she kills one of her more abusive clients, unwittingly setting a revolution into motion. When her pimp goes back on his promise to set her free, she enters her fast motion and kills "the man who hurt her the most," who happens to be the Somdet Chaopraya, regent to the country's Child Queen, and the country dissolves into chaos immediately following news of his death (271). When Emiko's "stutter motion" becomes "fast, almost a blur … strangely and suddenly graceful," the being who was supposed to be programmed, controlled, and owned becomes the most unpredictable force in the city (268). When the reader shifts toward this larger, citywide perspective of the networked structures of the government and corporations, the novel's close-up examination of Emiko's subjective willpower fades quickly into the background: the globally reaching change that she brings about takes place far beyond the level of the individual.

This human automaton's function in the novel, then, is two-fold. In the first case, Emiko provides a point of sympathetic identification and narrative focalization indirectly related to the genetic modification that is otherwise invisible to us. This character demands the reader's sympathy without appealing, as Hageman has also observed, either to a stable concept of humanity or to a discourse of the "natural" (293). As Sherryl Vint has written of the posthuman as a figure in sf, "it is imperative that we develop an ethically responsible model of embodied posthuman subjectivity which enlarges rather than decreases the range of bodies that matter" (190). *The Windup Girl* participates in just such an enlargement of the horizons of our sympathy, and of the range of bodies that matter, gesturing toward the point beyond which we can even detect the posthuman or post-natural traits of a body or organism. In these aspects, *The Windup Girl* gestures toward a humane-ness that extends well beyond humanity. But most importantly for our purposes, *The Windup Girl*'s ending encourages us to think about environmental and technoscientific problems on multiple scales simultaneously.

Into the Wild. In that endpoint of the novel's human programming subplot, readers figuratively zoom out from Anderson's close examination of whether Emiko's GM body could be said to act freely, to the citywide scale of Emiko's actions and their larger consequences. The novel's epilogue "zooms out" even further, to consider how the gene—invisible in its physical manifestation and often invisible in the ways it programs cells—connects to the deep time of the lives of species. The novel's multifaceted consideration of scale provides a model for scholarly considerations of scale, as well. In an article that helped to popularize the notion of the "anthropocene" among humanists, Dipesh Chakrabarty notes that we will have to consider the "species history" of

humanity in unprecedented ways in our theory and activism (212). According to Chakrabarty, histories of capital and even of empire are not adequate to the task of theorizing the anthropocene and humans' environmental impact: "to call human beings geological agents is to scale up our imagination of the human" (206). Likewise, genetic modification will count as a portion of humankind's geological agency, as the genes we develop will spread in time and space beyond the confines of humanity as a species.

The epilogue to *The Windup Girl* asks readers to consider this dimension of our species history and its scalar complexity. After her mechanical movements give way to superhuman ones and an upheaval and a plague wipe out Bangkok, Emiko finds herself in a scene of new beginnings. She meets Gibbons, the geneticist whom others had been searching for, and is promised fertile offspring that can be grown from the merest clipping of her hair. This epilogue looks forward to a future in which Emiko's offspring will be released into the wild, and where Gibbons can give Emiko the genetic future that her designers had sought to deny her. Through this scene of wilderness, the novel encourages us to consider the fate of genetic materials over the *longue durée* of an unforeseeable future. Hageman has noted that the future *The Windup Girl* imagines is consitutively queer in its refusal of the sf convention of the post-apocalyptic heterosexual couple (300). It is also an ending that asks readers to extrapolate along the line of the gene and to imagine the extreme long-term effects of each new species created or changed through genetic modification. In much the same way that Emiko's small act of vengeance causes a chain reaction that brings about cataclysmic change, the bit of hair that Gibbons will take promises to transform the biological makeup of the planet as a whole. What will be the long-term ecological impact, the novel asks here, of the GMOs we are currently creating? What will happen if they, too, go wild? Bacigalupi's novel encourages this big thinking about small things, a scale of ecological change and global responsibility that far outstrip what can be imagined within the corporate timeframes of quarterly earnings, annual reports, and strategic five-year plans to increase market share. Considering microscopic scales, ecological scales, and distributed agency is thus a particularly pressing challenge for humanists and environmentalists, and the narrative- and media-based tools for training the imagination to move between scales are there in Bacigalupi's sf work and other sf. Just as humanists have devised methods for shuttling among different cultural perspectives and different disciplinary forms of knowledge, perhaps we can also find ways to address—and envision—technoscientific problems in all their dimensions.

NOTES

1. The 2012 California *Official Voter Information Guide* describes Proposition 37 thus: "Requires labeling of food sold to consumers made from plants or animals with genetic material changed in specified ways. Prohibits marketing such food, or other processed food, as 'natural,'" and also describes the governmental costs associated with enacting the legislation (*California*). Whole Foods's announcement, five months after Proposition 37 was defeated, was covered on the front page of *The New York Times*

("Major Grocer to Label Foods with Gene-Modified Content"). As this article was going to press, and as a growing number of producers have begun to label "non-GMO" foods, the US House of Representatives voted to prevent nationwide laws that would require the labeling of GMO foods ("House Passes Bill to Prevent Mandatory GMO Labeling").

2. Hageman identifies Pioneer Hi-Bred International Incorporated (a DuPont subsidiary) as a hybrid seed company that, like the novel's AgriGen, is headquartered in Des Moines, Iowa; the subsidiary engineered genetically insertable vaccines in 2009 and 2010, which would have been in development upon *The Windup Girl*'s release (287). Monsanto, headquartered in Crevecoeur, Missouri, has been the target of much anti-GM activism.

3. Bacigalupi addresses a similar representational problem regarding the scale of agency in an interview with Adam-Troy Castro: "Our crises are all distributed ones, where everyone shares a little blame but can't credit that our small actions add up to a devastating whole. I would much prefer that someone like [the gene ripper] Gibbons were to blame. It would be so much simpler."

4. The chimerical GMO could also be seen as a representational throwback to a previous horizon of scientific possibility, the nuclear. Consider, for instance, the three-eyed fish near the nuclear power plant in the opening sequence of *The Simpsons* [date], which stands in for the unintended mutations that radioactive waste produces, unlike the more fine-tuned and intentional modifications that GMOs express. Accidental GMO effects are used in fiction as well, for instance, in Sam Raimi's *Spiderman* (2002), whose origin story swaps out the comics' radioactive spider for a genetically engineered spider.

5. See Robert Mitchell, *Bioart* (86–90), for an interesting counter-argument about the predominant interpretation of disgust in bioart. Looking toward Immanuel Kant's discussions of disgust and aesthetic framing, Mitchell claims that the frame can highlight the formal beauty of an object, "bringing something close … by suspending our habitual relationships to objects" (89). I would hold that, rather than inspiring ordinary disgust—and inspiring us to reach for our cleaning supplies—works of bioart inspire a sort of mitigated or intellectualized, rather than visceral, disgust.

6. See Cressey and "Plant Biotechnology: A Tarnished Promise," both part of a 2013 issue of *Nature* devoted to GMOs.

7. From *The Critique of Judgment*: "we call sublime what is absolutely large" and "our imagination strives to progress toward infinity, while our reason demands absolute totality as a real idea, and so our power of estimating the magnitude of things in the world of sense [i.e., the understanding or reason] is inadequate to that idea" (Kant §25, 103, 106).

8. *The Windup Girl* does use some more conventional versions of the sf grotesque in its consideration of the GMO, but usually only in passing. For instance, the novel mentions other windups like Emiko who work on farms and have "ten hands"—implicitly, they are "field hands." Such a representation, which plays no role in the plot, appears more readily as a pun, perhaps mentioned for the purpose of emphasizing the roles of windups as members of various underclasses (49).

9. Christy Tidwell has pointed out the stunning beauty of Bacigalupi's prose in describing posthuman figures in the short stories, collected in *Pump Six* (2008), that preceded *The Windup Girl*. Tidwell highlights a description in"The People of Sand and Slag" (2004) of swimming in a polluted ocean in which the swimmer "flashed through the ocean's metallic sheen like an eel out of history and when she surfaced, her naked body glistened with hundreds of iridescentt petroleum jewels" (64) which, according

to Tidwell "combines natural imagery … with descriptors associated with toxicity and modification" (100). The description of pollution as beautiful, as in *The Windup Girl*, provocatively undermines the aesthetic bases of environmental activism.

10. Fictions of nanotechnology (or nanopunk), too, have this potential, given that tiny machines might alter the body from within. Rather than being a quasi-machinic basis of life, however, the nanotechnological has, according to Colin Milburn, "techno-deconstructive effects [that] problematize the difference between the human and the extrahuman" (16). Greta Aiyu Niu makes the useful observation that cyberpunk often relies on "digital code or a binary system [that] separates mind from body, while nanopunk explores biological-machinic routes that are less clear cut" (75).

11. See also Canavan for an excellent discussion of Wald's "future perfect" and an explanation of a similar "pharmakon" logic of gene therapy as it relates to Huntington's disease.

12. For *The Matrix*, hundreds of digital cameras were set up in a circular formation in order to enable a virtual pan around the near-frozen figure of Keanu Reeves, mid-air, dodging CGI bullets (Argy). When they included a version of the effect in their videogame adaptation, *The Matrix Online*, Warner Brothers trademarked the name of this digital slow-motion-simulation effect as "bullet time"("Bullet Time").

13. From another perspective, in borrowing from the cinema, Bacigalupi, like a good many other contemporary novelists, is also likely imagining the book's possible future as a film. And in fact, according to Bacigalupi's Twitter account, *The Windup Girl* has already been optioned. In our contemporary media ecology, special-effects technology can play a major role in the imagination of the sf novel.

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ABSTRACT

This article raises questions about the aesthetics of scale as they appear relative to genetically modified organisms in science fiction and especially in Paolo Bacigalupi's *The Windup Girl* (2009). Bacigalupi makes the unusual choice of representing GMOs largely through science-fictional tropes of automatism rather than the grotesque. Because of this choice, *The Windup Girl* inventively enables readers to relate to the very small spatial scales and the long temporal scales at which the genome and its effects are most visible. The article suggests that science fiction has particular flexibility with the aesthetics of scale, particularly where technoscientific phenomena have profound consequences that take place at nonhuman scales.