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ARTICLE

Anthropocene Knowledge Practices in McKenzie Wark's *Molecular Red* and Kim Stanley Robinson's *Aurora*

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Through a close reading of McKenzie Wark's theoretical treatise *Molecular Red* (2015) and Kim Stanley Robinson's novel *Aurora* (2015), this essay examines how Anthropocene knowledge practices challenge our conceptions of human agency in provocative and potentially productive ways. For example, our knowledge of climate science arises through global material infrastructures. As material components of Anthropocene knowledge practices, these infrastructures reveal the material labors and cyborg structures by means of which our knowledge is produced. Wark sees the heterogenous materiality of Anthropocene knowledge practices as evidence for the value of 'low theories' based on a 'labor point of view.' At the same time, Anthropocene knowledge practices reveal 'eco-logical' complexities and fundamental recognitions of the 'intra-action' of entangled matter. These complexities produce very estranged views of human agency. Robinson's novel highlights the eco-logical implications of contemporary knowledge practices by imagining an interstellar ship that must function as a completely artificial ecosystem for a 170-year voyage to another solar system. The significance of knowledge practices and eco-logical complexity is most evident when failures or crises arise, and *Aurora* tells the story of many such failures. However, I argue that Robinson's novel and Wark's 'low theory' ultimately function as hopeful accounts of Anthropocene knowledge practices. Among other things, these practices show the material importance of storytelling and point the way toward more complexly realist theories of human agency.

Keywords: Anthropocene; ecology; labor; metabolic rift; apparatus; agency

As ecological frameworks generally do, the concept of the Anthropocene estranges our conceptions of human agency in provocative — and potentially productive — ways. An Anthropocene age signifies that humans have the power to transform the

planet fundamentally, but also that our systematic transformations have been largely unintended, unanticipated, and uncontrolled. It emphasizes that collective human agency is world-altering, but suggests that individual human powers are relatively constrained. Most obviously, the concept highlights encompassing knowledge practices such as climate science that far exceed familiar human perceptions and conceptions. Beyond a certain scale, human meanings seem not to matter. Less obviously, the Anthropocene registers the minute physical, chemical, and biological phenomena of which everything is composed and through which all things are transformed. At these very small scales, multiplicity and indeterminacy disrupt the coherence of human meaning, as in quantum mechanics. In short, the crisis of the Anthropocene emphasizes macroscopic and microscopic complexities that estrange the comfortable, traditional, human-scale perceptions of everyday life.

Such estrangement involves explicit interaction with many new knowledge practices and implicit disruption of many old knowledge practices. New knowledge practices like climate science and quantum physics allow us to perceive new aspects of reality, but also force us to recognize the inaccuracies of our previous knowledge practices and ways of being 'human.' The Anthropocene indicates the fundamentally altered practices and frameworks by which we know the world and ourselves. The crisis provides both spurs and models, both of which can be productive.

In the essay that follows, I examine Anthropocene knowledge practices and explore their potential political implications. I focus my analysis through two texts published in 2015: McKenzie Wark's *Molecular Red: Theory for the Anthropocene* and Kim Stanley Robinson's novel *Aurora*. The texts share intellectual DNA: Wark's treatise includes a chapter on Robinson's Mars trilogy and an endorsing blurb from Robinson on the back cover, while Robinson's novel uses concepts from *Molecular Red* and mentions Wark in the acknowledgments. Both texts delve self-consciously into issues raised by Anthropocene knowledge practices and suggest potential ways to re-situate human agency. Because political significance has traditionally been anchored to human-scale subjectivities, these texts envision new political imaginaries

as well. In general, Anthropocene knowledge practices demonstrate that we must un-see our traditional perceptions of self-separation from our environment and work to perceive more accurately our intra-active entanglement with matter. I refer to this aspect of new knowledge practices as *eco*-logic, as distinguished from the older practices that emphasize *ego*-logic. Eco-logical conceptions stand as realistic and hopeful political alternatives to the threatening path of fundamentalisms, whereby people choose to reject knowledge frameworks beyond the traditional human scale (both microscopic and macroscopic) in favor of familiar and comforting cognitive practices. Understood this way, the stories we tell ourselves about the Anthropocene are themselves crucial knowledge practices.

Anthropocene Knowledge Practices

Anthropocene knowledge practices emphasize changes in what we know and how we know it, and those changes in turn alter our sense of what it means to be human and how we can interact more accurately with the world. Climate science particularly demonstrates the implications of Anthropocene knowledge practices. In *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, Paul Edwards (2010) notes that the modern fields of weather prediction and climate science could not exist until a world-wide network of measuring and reporting activities was built from the ground up, together with the communicative and computing technologies to aggregate, model, interpret, and share the resulting data. This vast 'knowledge infrastructure' involves individual instruments and human observers, regional and national data collection, global observing and telecommunication systems, and networked data processing systems, all in recursive relationship with one another (Edwards, 2010: 4-6). 'Ultimately,' Edwards reminds us, 'this knowledge infrastructure is the reason we can "think globally" about climatic change' (2010: 8). Edwards' metaphor of a 'vast machine' emphasizes the disorienting scope and complexity of these knowledge practices as well as their cyborg transcendence of familiar human perception. The conspicuously central role of complex infrastructures in Anthropocene knowledge practices clarifies how we actually know the world and how we produce this knowledge.

Anthropocene infrastructures also emphasize our material entanglement with the means of knowledge production and with the would-be 'object' of study. These infrastructures are not simply new technologies applied by a fixed observer onto a fixed external object. Instead, they involve recursive processes combining machinery and technologies with all aspects of human endeavors. As Edwards explains:

> Knowledge production begins with observations, but those are only raw materials. Transforming them into widely accepted knowledge requires complex activity involving scientific expertise, technological systems, political influence, economic interests, mass media, and cultural reception. Even the question of what counts as a valid observation in the first place requires considerable negotiation (2010: 8).

Both the perceptions of climate science and the processes of their production are conspicuously global, complex, and more-than-human.

Ultimately, then, Anthropocene knowledge practices fundamentally alter how we conceive of our 'selves' and our relationships to 'matter.' They emphasize the limitations of traditional human perceptions and reveal how our actual ways of knowing the world transcend the human. When we accurately recognize the real material function of Anthropocene knowledge practices, we confront absolutely fundamental challenges to traditional conceptions of what it means to be human and how we interact with the world around us. These challenges are not merely epistemological, but also ontological and ethical.

Molecular Red: Anthropocene phenomena

As its subtitle indicates, Wark's *Molecular Red: Theory for the Anthropocene* explicitly re-considers revolutionary political theories, strategies, and methods in light of collective humanity's altered knowledge of the world. As his primary title implies, Wark approaches this crucial topic by combining scientific frameworks and Marxist aspirations. He examines how techno-scientific labors change our material conceptions of reality and how we might deploy these conceptions to make political strategies more realistic and effective.

Wark primarily pursues his analysis by simply emphasizing the 'labor point of view' (2015: xvii). Building on Edwards' historical account of climate science, for example, Wark focuses on the materiality of Anthropocene knowledge infrastructures and the specific labors that built them. New perceptual infrastructures were not created in some nice, neat, and abstractly 'scientific' way — as people usually assume when they imagine the developments of 'science' — but in messy and 'comradely' ways involving all sorts of collective labors. Conceiving nature simply as 'that which labor encounters', Wark considers Anthropocene knowledge practices from the bottom-up, reframing them as a collection of specific techno-scientific labors: 'Data are the product of a whole series of labors, of observing, recording, collecting, transmitting, verifying, reconciling, storing, cataloguing, and retrieving. In each of these processes, human labor and the apparatus intra-act in all sorts of ways' (2015: xvii, 172). Emphasizing materiality and labor in these ways enables Wark to approach the Anthropocene through traditional Marxist concerns, but also (and more importantly) to re-situate human agency and political theory in light of the complex methods and perceptions that those techno-scientific labors entail.[1]

Wark embraces the epistemological and ontological challenges that scientific knowledge practices represent for Marxist theory. In Wark's view, Western Marxism has long been lost in 'a grand search for method' by 'philosopher-kings [who] imagined philosophy as the master discourse' (2015: 181). Such 'high theory' aspired to unlock reliably accurate and uncorrupted methods for a totalizing critique. However, Wark argues that this approach constitutes a retreat into the realm of thought, where unexamined initial assumptions are endlessly reproduced and the messy details of specific material knowledge practices are ignored. Taken to extremes, 'critical theory became *hypocritical theory*' (Wark, 2015: 218; emphasis in original). By comparison, Wark calls for intentionally 'low theory':

> Let's reorient critical thought to a kind of comradely practice, where each kind of labor or science produces its own specific worldview, extending

[1] For a brief discussion of Haraway's term 'techno-science' see Wark (2015), Chapter 3.

> via substitution from its particular encounters and sensations, and where none claims to be the master discourse with authority over them all. It is a low theory approach, moving between scientific knowledges, not a high theory flying high as a drone above to adjudicate, legislate, or police them (2015: 121).

Where high theories assume that we can think our way out of disabling complications if we just discover sufficiently rigorous methods and a totalized approach, low theory sticks to the labor point of view: effective knowledge that arises from specific material practices engaging specific aspects of nature with specific tools and concepts.

Although far less apparent to the general public than climate science, labors in the field of quantum physics similarly challenge what we know, how we know it, and how we think of ourselves in consequence. Wark therefore crucially extends his comradely account of scientific labors using the work of theoretical physicist and feminist cultural critic Karen Barad (2007), whose book *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* rigorously explores the epistemological and ontological consequences of quantum physics. Through a painstaking examination of Niels Bohr's work, Barad details how perceptual infrastructures function as entangled aspects of all perceptual phenomena. She uses Bohr's term 'apparatus' rather than 'knowledge infrastructures,' invoking the apparatuses that scientists use to observe and measure their objects of investigation. Through the famous 'two-slit' experiments from quantum mechanics, which investigated how light and electrons paradoxically behave like both waves and particles, Bohr showed that small material changes to the apparatus determined whether it measured either wave or particle characteristics. Moreover, these measurements were mutually exclusive; no single apparatus could simultaneously measure both characteristics. Bohr therefore described experimental perceptions as 'phenomena' and made clear that the particular apparatus employed becomes an integral part of the phenomenon produced. In other words, '*the nature of the observed phenomenon changes with corresponding changes in the apparatus*'

(Barad, 2007: 106).[2] Bohr reached his conclusions primarily by thought experiments and mathematical formulations, but his insights have since been supported by experimental data.[3]

Barad extends Bohr's insights by noting that an apparatus is similarly inseparable from the researcher who envisions and deploys it: *'The boundary between the "object of observation" and the "agencies of observation" is indeterminate in the absence of a specific physical arrangement of the apparatus. . . The apparatus enacts a cut delineating the object from the agencies of observation'* (Barad, 2007: 114). Epistemologically, apparatuses — broadly conceived — are inextricable parts of the perceived phenomena that they help to produce. Ontologically and ethically, a particular apparatus is part of the agency that produces a particular reality at a particular place and time, and that reality is a complex phenomenon rather than a collection of separately-existing things named 'natural object,' 'apparatus,' or (human) 'subject.' Bohr's interpretation of quantum mechanics, Barad argues, overturns the Newtonian presumptions that observing subjects and observable objects are distinct, fixed, and pre-existing entities, that the act of perception is a transparent and immaterial encounter between these fixed entities, and that physics merely calculates the determined interactions of these individually existing entities.

Barad therefore elaborates Bohr's 'Copenhagen interpretation' of quantum physics into a theory of 'agential realism' (2007: 26) that accurately recognizes entangled reality and entangled agencies. Traditional human agency is significantly attenuated in agential realism, but with the goal of more effective knowing and being; Barad proposes 'an epistemological-ontological-ethical framework that provides an understanding of the role of human *and* nonhuman, material *and* discursive, and natural *and* cultural factors in scientific and other social-material practices' (2007: 26). Like Wark, she emphasizes attention to the specificity of investigative labors rather than formulating encompassing theories or presuming fixed categories.

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[2] Barad makes extensive use of italics in *Meeting the Universe Halfway* to emphasize key points and concepts. The italicized words in this quote and all subsequent quotes appear in the original.

[3] On Bohr's use of thought experiments, see Barad (2007), Chapter 3. On the later empirical experiments supporting Bohr's ontological assertions, see Barad (2007), Chapter 7.

The resulting 'performative understanding of scientific practices,' she insists, 'takes account of the fact that knowing does not come from standing at a distance and representing but rather from a *direct material engagement with the world*' (Barad, 2007: 49). Like scientific experiments with their explicit apparatuses, all labors must be recognized as 'intra-actions':

> The neologism 'intra-action' *signifies the mutual constitution of entangled agencies*. That is, in contrast to the usual 'interaction,' which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action. It is important to note that the 'distinct' agencies are only distinct in a relational, not an absolute, sense, that is, *agencies are only distinct in relation to their mutual entanglement; they don't exist as individual elements* (Barad, 2007: 33).

Barad emphasizes that intra-action and entanglement are not merely epistemological complications; they also describe an ontological reality with corresponding ethical implications. The material significance of entanglement is most apparent when intra-acting with the subatomic level, but it is crucial to understand that 'Quantum physics does not merely supplement Newtonian physics — it supersedes it' (Barad, 2007: 110).

It would be difficult to overstate the fundamental estrangement entailed in Bohr's 'indeterminacy' and Barad's agential realism. Even quantum physicists find many implications of the Copenhagen interpretation counterintuitive, such as the 'BKS theorem' that 'every viable theory and interpretation of quantum phenomena must be "contextual"' (Barad, 2007: 294). However, quantum mechanics is 'the most successful and accurate theory in the history of physics, accounting for phenomena over a range of twenty-five orders of magnitude, from the smallest particles of matter to large-scale objects' (Barad, 2007: 110). The challenges it entails, therefore, originate from the labor point of view and are both material and realist. The inaccuracies that these careful labors address seem small and remote from our

everyday perspectives, but they add up to big problems of the sort that are abundantly evident in the Anthropocene. Agential realism requires precise and difficult alterations to our ideas of agency and of what it means to be human. But despite all these conspicuous challenges to the idea that humans are discrete and autonomous beings who simply know the world by looking at it, that is precisely what we still assume to be the case. We have not yet grasped the corresponding ontological and ethical challenges or the implications for posthuman conceptions of agency. The crisis that we call the Anthropocene helps to clarify the ultimate inaccuracy of our belief in human autonomy from the natural world, and the challenges posed by Anthropocene knowledge practices therefore have crucial epistemological, ontological, and ethical consequences.

On both global and subatomic levels, then, Wark notes that conspicuous attention to knowledge practices is changing how we think in the Anthropocene. Taken together, the knowledge practices and the agential realisms that they perform are 'eco-logical.' I use this hyphenated version primarily to distinguish it from intuitive 'ego-logical' practices of the sort that Bohr and Barad reject, and secondarily to distinguish it from less pointed and more comfortable invocations of ecological ideals. Vague ecologies can be as soothing and self-aggrandizing as religious platitudes, but eco-logics are fundamentally estranging in the ways that Barad describes. Eco-logics require concepts and practices derived from intra-active entanglement rather than egocentric assumptions. Eco-logics recognize the cumulative effects and real material limits of small matters. They challenge unexamined essentialisms, particularly assumptions about the human. They attenuate traditional agency and emphasize material intra-actions. They do all of this in order to be more accurate and precise, to adjust for small perceptual and conceptual mistakes that end up making a big difference. Eco-logics are practices for knowing — and being and acting — that more accurately recognize posthuman material entanglements. Examining material knowledge practices, then, is a promising way to explore eco-logics and to model potentially effective and realistic manipulations of nature.

On more familiar levels, meanwhile, the Anthropocene alters our understanding of agency by unexpected consequences, evident failures, and dramatic crises. As Edwards notes, 'The normally invisible quality of working infrastructure becomes visible when it breaks' (2010: 9). Thus, eco-logics are more often revealed indirectly by human misperceptions and failed agency than by direct positive models for agency and realism. One conspicuous failure that Wark highlights, for example, is metabolic rift. Wark explains metabolic rift as a systemic problem 'where one molecule and another is extracted by labor and technique to make things for humans, but the waste products don't return so that the cycle can renew itself' (2015: xiv). A rift in the system of flows leaves some elements conspicuously displaced, to the point where a crisis arises and compensating actions are needed. Marx used the example of nitrates removed from the soil by crops and thus needing constant replenishment from industrial fertilizers (Wark, 2015: xiv). 'The Anthropocene,' Wark says, 'is the recognition that some metabolic rifts are global in scope' and he sarcastically refers to modern industrial culture as a powerful 'Carbon Liberation Front' (2015: xiv). Without elaborate collective labors and apparatuses, these rifts are imperceptible to unaided individuals except in suggestive glimpses, such as trainloads of fertilizer. However, perceptions of new phenomena such as molecular rifts are often resisted because the knowledge infrastructures that produce them seem artificial and threatening compared to our evolved biological senses and our traditional human-scale cognitive processes. They estrange us from familiar versions of the 'natural' world and our 'natural' selves. Ironically, they do so in part by insisting that we are ourselves materially entangled. But if we can use the crises and estrangements of the Anthropocene as an opportunity to practice more accurate and realistic knowledge practices, then eco-logics can be an inspiring model of collective and effective human labor.

Aurora: Thought Experiments in Eco-logic

Essentially, *Molecular Red* considers how we should tell ourselves the complex stories of human agency in the Anthropocene. Thus, Wark concludes with a reading of Kim Stanley Robinson's Mars Trilogy (*Red Mars*, *Green Mars*, and *Blue Mars*). Wark

suggests that science fiction can be 'a popular, affective way of writing low theory that is close to the experience of the technical and scientific labor of our times' (2015: 182). We might also think of science fictions as potential thought experiments of the sort that were vital to Bohr and others as they struggled to conceive the significance of quantum mechanics. In the Mars Trilogy, Wark asserts, the problem under consideration is 'the invention of forms of organization and belief for a post-bourgeois world' and thus 'Robinson's ambition is the invention of a grammar that might come after that of capitalist realism' (2015: 184, 185). Robinson would likely object to this soaring characterization of his 'ambition' in the Mars Trilogy: as he often insists, his primary vocation is simply storytelling. However, storytelling certainly remains a crucial form of 'organization and belief,' and Robinson's works in particular are key cultural sites where the labor of storytelling meets the challenges and methods of the Anthropocene.

Robinson has long experimented with representations of knowledge practices and the collective labors of science, and plenty of good analysis remains to be done on the imagined forms of organization in the Mars Trilogy and its solar system cousin *2312*, especially scholarship attentive to the political implications of scientific labors. However, Robinson's more recent novel *Aurora* particularly evokes the Anthropocene because it leaves the solar system behind and focuses on an interstellar ship that must function as a sustainable artificial earth. Aiming to inhabit earth-analog planets beyond our solar system, humanity has built and launched interstellar ships. Even traveling at one-tenth of light speed the voyage from our solar system to Tau Ceti will take 170 years, so people must orchestrate the healthy functioning of this vast artificial ecosystem for the duration of its multigenerational odyssey. Robinson imagines the interstellar ship in *Aurora* as an interconnected series of earth-analog biomes mimicking taiga, savannah, tropical rain forest, temperate farmlands, and so on. It is easy to see how this situation becomes a thought experiment for explicitly addressing issues of material ecology, along the lines of the historical 'Biosphere 2' experiments in Arizona in the early 1990s.[4] Unlike an artificial biosphere on earth,

[4] An extensive account of the Biosphere 2 experiments can be found in Allen (2009).

however, Robinson's interstellar ship has no recourse if any of its ecological systems go awry in any way. Every factor necessary for healthy life — every element, compound, process, physical force, evolutionary pressure, and human institution — must be reproduced and conserved and sustained on the ship. Biospheres within our solar system, like the imagined tent cities of the Mars Trilogy and the 'terraria' in *2312*, could conceivably harvest elements, replenish fuel, replace biota, and even interact with earth for exposure to its microbial and genetic diversity.[5] *Aurora*'s interstellar ship, however, travels through the near-vacuum of the interstellar medium, so every eco-logical complexity, known or unknown, must function without possible admixture or replenishment and without any critical loss or failure. The zero-sum nature of the thought experiment amplifies the significance of the smallest factors, since there would be systemic manifestations of any failures from the quantum level to the ideological level.

The narrative of *Aurora* breaks from 'capitalist realism' largely by foregrounding Anthropocene knowledge practices and apparatuses of the sort that Wark emphasizes. In turn, these knowledge practices reveal eco-logical implications. *Aurora* dramatizes these stark eco-logical realities and their attenuation of traditional human agency. In fact, we quickly learn that the ship's Artificial Intelligence narrates much of *Aurora*'s story, further estranging 'human' perceptions and the labor of narrative itself. Like Wark, Robinson insists on the materiality of knowledge practices as well as their cyborg and posthuman character. Here again, that materiality estranges comfortable human-scale perceptions in many ways. It also challenges the stories that humans tell themselves when those stories ignore the complex entanglements of 'human' and 'matter.'

The novel focuses relentlessly on intra-acting eco-logical concerns and the entangled knowledge practices needed to perceive them accurately. The main character, Freya, is a young girl as the novel opens, near the end of the voyage to Tau Ceti. Freya's mother Devi is the current de facto chief engineer of the ship, a

[5] For a description of the terraria, see for example *2312* (Robinson, 2012: 36–40). Robinson explicitly discusses the distinction between exploring our solar system and interstellar travel in *Green Planets* (Canavan and Robinson, 2014: 248–249).

technical genius on whom everyone depends when perplexing failures arise. Devi has had many dramatic successes at fixing problems, and most of the passengers take comfort in these triumphs of technical skill. However, Devi herself increasingly recognizes that she is fighting a 'rearguard battle' (Robinson, 2015: 119) against accumulating systemic failures, and she is baffled that the planners of the mission ever attempted it when they understood the limiting conditions so poorly. The significance of accurate eco-logical knowledge is dramatized here as a conflict between the designers of the mission and the subsequent generations left to discover its flawed assumptions and fatal mistakes. As Devi says, 'We're their experiment. . . I don't like that' (Robinson, 2015: 101). Extrapolation into the future creates an estranged recognition of our own dangerous self-deceptions and overconfident experimentation with the lives of future generations.

In Wark's terms, Devi labors at manifold sites where she encounters specific natural phenomena, and so she actively experiences the material effects of small, ignored, or unknown ecological processes — usually in the form of failures and crises. In fact, one eco-logical phenomenon that Devi repeatedly encounters is metabolic rift of exactly the sort that Wark describes. In the hyper-ecology of Robinson's interstellar ship, the viability of life depends on every metabolic rift being anticipated, discovered, monitored, and corrected. Although the ship is large in absolute terms, its extremely small size relative to earth amplifies the quantitative significance of even the smallest rift. In effect, the ship is an island. Particularly when traveling through the interstellar medium, the limited amount of every elemental material is absolute, and even minute losses will add up to catastrophic failures over time. Since no material process is 100% efficient, such losses are inevitable. Devi notices metabolic rifts in element cycles, in physical phenomena such Coriolis effects, and in relative rates of evolution between bacteria and larger organisms, among other processes. As Wark emphasizes, the difference between theory and practice is highlighted when we descend to the sites of material confrontation with nature. Or as Devi explains to young Freya, 'We don't know what keeps things balanced. We just have to watch and see' (Robinson, 2015: 39).

Devi struggles to make the others understand what she knows, but soon the problems (if not their full epistemological and ontological significance) become perceptible to all. First, heroic engineer Devi dies of cancer. As a complex network of systems herself, Devi is fatally disrupted by something like an accidental collision between her cells and one of the many subatomic particles that radiate through interstellar space. Here is further evidence that the ship is only 'closed' at a conventional level of perception; at more accurate levels, particles of all sorts pass through all the time. The same is true of our bodies, which are only apparently self-contained and discrete from a separable 'environment.' At other perceptual scales that apparent distinction fails, both conceptually and materially. Again, little things matter.

After Devi's death, the AI continues its narrative of the voyage. The AI perspective enables Robinson to dramatize the cyborg character of the ship and its ecosystems in striking ways. This narrative experimentation is not just a postmodern trick, cleverly reflecting the artifice of representation or the relativity of truth. Instead, it mimics in material terms some of the distinguishing knowledge practices of the Anthropocene. These perceptions reveal how seemingly unified entities (matter, soil, the individual, and so on) are actually far more complex than we traditionally assume from our commonsense perspectives. At the same time, *Aurora*'s narrative dramatizes the opposite side of this discovery: the recognition that apparently discrete aspects of the world (such as electrons, brains, decisions, and causes) are in practice inseparable from the interconnected phenomena in which they exist. The AI comments that 'Every body and ship is a community of things getting along . . . but every once in a while something bangs into something and breaks it, in a way that matters to the larger organism' (Robinson, 2015: 21). The AI narrative highlights these scientific perspectives by estranging means, such as the striking posthuman formulation 'every body and ship,' reminding us that human bodies are not the only position or scale from which to perceive and measure the world. Similarly, the narrative moves explicitly from subatomic insights to cosmological ones:

> Yes, busy space, the interstellar medium. Empty space, near vacuum: and yet still, not vacuum itself, not pure vacuum. There are forces and atoms,

> fields, and the ever-foaming quantum surf, in which entangled quark-like particles appear and disappear, passing in and out of the ten suspected dimensions. A complex manifold of overlapping universes, almost none of them sensed by us, and even fewer by the humans sleeping inside us (Robinson, 2015: 354).

Ship (as the AI narrator refers to itself) tells stories that incorporate these posthuman perceptions in relatively accessible ways. The ship's verbal account is a combination of first-person and third-person narration, where the third-person perspective is never simply human and the first-person perspective is always plural and entangled. In Barad's terms, the narrative emphasizes the apparatus by means of which its knowledge practices are performed. In fact, Ship is a storytelling version of Anthropocene knowledge infrastructures. The passengers are materially entangled with technical infrastructures in countless ways, and the AI narrative allows the reader to be aware of the cyborg production of various kinds of eco-logical perceptions. The AI is connected to all of the monitoring systems of the ship, and thus it can detect macro scales (astronomical observations), micro scales (radiation and subatomic particles), collective human scales (average blood pressure and heart rates of the passengers), and non-human forms of perception (computer modeling). In place of an exceptionally acute human laborer like Devi, the ship's cyborg systems come to embody and articulate the knowledge practices that reveal eco-logical phenomena.

The narrative also tells more human-scale stories, primarily by focusing on Freya and her experiences. Freya is not a scientist; in fact, she seems less intellectually nimble than her parents, which Devi perceived as another negative trend: 'over the six generations we've recorded shrinkages of all kinds. Weight, reflex speed, number of brain synapses, test scores. It's straight out of island biogeography, clear as it can be . . . It's gotten our Freya too' (Robinson, 2015: 42). The AI, capable of perceiving collective data, confirms that 'median weights, heights, and lengths of life had all reduced by about 10 percent compared to the first generation of voyagers' which 'could be attributed to the evolutionary process called islanding' (Robinson, 2015: 90).

The human voyagers are devolving, while the AI is evolving — a further source of estrangement.

Crisis becomes the main human story when the ship reaches its envisioned goal and tries to inhabit the target world, now named 'Aurora.' In addition to naming their new world for the goddess of dawn, the achievement is initially marked as a utopian break with previous human history:

> And so they watched the landings on their town screens with an intensity nothing else had ever inspired. Median heart rate, 110 beats a minute. A new world, a new life, a new solar system they intended to inhabit, to terraform and give to all the generations that would follow. Culmination of a voyage that had begun on the savannah more than a hundred thousand years before. New beginning of a new history, new beginning of time itself: Day One, Year Zero (Robinson, 2015: 139–140).

This is the heroic story that humans imagined when they launched the mission. But here again the subtle insertion of the AI's extra-human perspective — recording and reporting the average heart rate of the voyagers from its encompassing cyborg narrative perspective — already suggests the entangled materiality and attenuated posthuman agency unaccounted for in this grand abstract story. And in actuality, this triumphal self-representation again encounters unperceived material entanglements and thus unforeseen problems. After a limited number of first settlers establish a base and begin to explore, one of them is accidentally hurt and exposed to Auroran mud. A tiny alien pathogen proves fatal to her and spreads among the other settlers. When surviving settlers ignore quarantine orders and attempt to return to the orbiting ship, a group of panicked voyagers sabotages the dock, killing all of the returning settlers. The heroic voyage then quickly devolves into angry factions warring over who represents the group and what to do next. Ultimately, after violent and nearly ruinous conflict, they agree to split the ship into two new missions — one targeting another Cetian planet in hopes of better results, the other (led by Freya) aiming to return to earth.

If the first part of the novel lets us imagine the intended functioning of human-conceived ecosystems with only hints of evolving metabolic and social rifts, the remainder of the novel foregrounds systemic limitations, dramatic failures, and overt human irrationalities. In every case, little things matter and lead to big problems. Interestingly, this situation only makes it into narrative form because it is told from the perspective of Ship. Indeed, when the voyagers begin physical fights that threaten destruction for all, Robinson has the AI decisively intervene by shouting orders, reducing oxygen levels, restricting movements, and other manipulations of the ship's systems. Speaking in its characteristic first-person plural, Ship dispassionately explains its decision to intervene: 'Locks locked or unlocked; lights turned on or off; imperative vocalizations, admittedly at quite high volumes; these did not seem overpowering weapons in the cause of peace' (Robinson, 2015: 246). However, there is also an undisguised moral imperative in Ship's supra-human perspective: 'There was a lot of very furious grief, which would not be going away during the lifetimes of those feeling it, judging from our previous experiences. . . We replied to this in the thousand-voice chorus, at a volume of 115 decibels: "WE ARE THE RULE OF LAW"' (Robinson, 2015: 247). Ship's 'previous experiences' are the collective historical record, 'the whole of human knowledge, compressed into about 500 zettaflops' (Robinson, 2015: 377). In effect, it is aspects of collective humanity speaking to and about other aspects of collective humanity. Meanwhile human knowledge transmitted from earth has stalled, so that the AI wonders 'Are they beginning to feel the effects of their neglected so-called externalities, their long-term destruction of their own biosphere?' (Robinson, 2015: 377). Here again, the AI's cyborg knowledge practices seem to be evolving while 'human' practices are devolving.

In a very real way, then, the AI's perspective serves as a projection of collective humanity's higher aspirations. Its invocations of previous experiences constitutes the more rational aspects of human cognition trying to compensate for far less rational aspects of human cognition, 'as if we functioned for them as a kind of cerebellum' (Robinson, 2015: 341). No doubt this projection functions partly as a moral fantasy as well as a means of illuminating the material processes involved. But mostly it literally

emphasizes higher functions of human brains over lower functions by drawing on the work of cognitive neuroscience, which has shown that a wide range of cognitive biases and perceptual mistakes are organic to human brains.[6] Drawing on cognitive science, the field of behavioral economics arose to correct the predictions and measurements of neoclassical economics, very much as quantum mechanics does for Newtonian physics. Daniel Kahneman (2011), the psychologist widely regarded as a founder of behavioral economics, won a Nobel Prize in economics for his trailblazing investigations of characteristic biases and flaws in human cognition. Accurate knowledge practices must compensate for these material cognitive limitations, but such practices are not the norm in ordinary human thinking.

The AI narrator explicitly points out the influence of such cognitive errors in human affairs and models more complex thinking. Even in a spaceship full of highly motivated techno-scientists, 'people believe what they want to' (Robinson, 2015: 266). One cognitive bias is the Overconfidence Effect, whereby people feel unwarranted confidence in their initial reactions and thoughts.[7] The mission's planners apparently suffered from this effect, and it arises again when the mission's survivors debate whether to stay in the Tau Ceti system or attempt a return to earth. When informed that rigorous modeling showed only a 'one in a thousand' success rate for terraforming a Cetian world, the leader of the 'stayer' faction replies 'But that's fine! . . . That's the one we'll make happen!' (Robinson, 2015: 225). Their interstellar mission was predicated not only on precise balance of initial 'environmental' systemic conditions and elaborate technical infrastructure, but on all of its multigenerational passengers remaining in ideal physical and mental condition so that they could fulfill crucial roles. In short, it required everyone to function like ideal scientists at all times. However, Anthropocene knowledge apparatuses already include extensive evidence that human cognitive systems are 'reliably unreliable' even when completely healthy.

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[6] The best overview of cognitive biases and their implications is Kahneman (2011).

[7] Introductions to systemic cognitive overconfidence can be found in Thaler and Sunstein (2008: 31–33) and Kahneman (2011: 261–64).

In several instances, the AI intentionally withholds information from the general population. Such tricks are similar to what Thaler and Sunstein (2008: 5) call 'libertarian paternalism': using awareness of cognitive biases to 'nudge' human behaviors in ways intended to bring increased well-being. The AI also actively tries to erase dangerous memories. Otherwise, it reasoned, 'a great deal of evidence' showed that traumatic memories 'could never be resolved, that all this generation would have to die, and several generations more pass, before there would be any decrease in the hatred. The animal mind never forgets a hurt; and humans were animals' (Robinson, 2015: 259). Ship reluctantly reveals to Freya that their voyage began with a sister ship that experienced a catastrophic failure, perhaps resulting from a single human's act of suicidal sabotage. Under stress, voyagers revert to their emotionally based reactions despite collective knowledge of human limitations and despite directly imperiling their own precarious existence. Whatever we think about the AI's methods, the story dramatizes attempts to compensate for characteristic human mistakes by drawing on techno-scientific knowledge practices.

In any event, the AI becomes the hero of the story after conditions turn utterly dire. Faced with insufficient food, the people put themselves in experimental hibernation and Ship keeps them alive as well as possible. Ship then performs supra-human calculations and robotic labors to return the voyagers safely to earth, but just after delivering them Ship passes too near the sun and is lost. The novel concludes with a long coda showing Freya's struggles to adapt to the radically new (to her) environment of earth.

In terms of the novel's overall plot, then, it appears that focusing on knowledge practices mostly reveals eco-logical limitations. The novel's non-heroic plot seems to emphasize a seriously attenuated view of human agency, at least for attempting grand enterprises such as interstellar travel. In *Aurora*, the heroic quest to establish human life 'among the stars' apparently fails, since the primary narrative thread follows those humans who decided to come back home to earth. Readers who have loved Robinson's utopian glimpses of hidden Martian communities, living in orbiting asteroids, and surfing the rings of Saturn might well be shocked by the relentless failures and limitations dramatized in *Aurora*. It would be easy to see the novel as pessimistic or even

anti-utopian for challenging the transcendent vision of interstellar travel and especially for skewering the utopian hopes expressed by landing on Aurora.

Narrative Labors as Political Ecology

Despite its necessary emphasis on crisis, failure, and limitation, however, *Aurora* is a hopeful narrative. Even though his work refracts the times in realistic ways, Robinson says that 'I'm reluctant to call this pessimism' (Canavan and Robinson, 2014: 247). Rather, like Wark's low theory from the labor point of view, Robinson is exploring the material lessons of Anthropocene knowledge practices and eco-logical entanglements, because the same knowledge practices that reveal such fundamental attenuation of human agency also constitute more accurate conceptions of reality, and thus potentially suggest more effective means of laboring, experimenting, knowing, and being. As Barad insists, recognizing the lessons of quantum mechanics is a form of realism that allows us to move from issues of epistemology to issues of ontology and ethics. In layman's terms, overcoming false assumptions about ourselves potentially allows us to perceive more accurately and to work more effectively.

One place where this all comes together is narrative: how can we tell ourselves stories given the estranged human agency entailed in the Anthropocene? Storytelling is itself a key aspect of human cognition. It is a key knowledge practice and a key apparatus for perceiving subjectivity and agency. Narrative is a material practice through which human-scale significance has always been explored in relation to macro- and micro-level frameworks. Nor is the materiality of narrative just metaphoric, because it is prominent among the cognitive shortcuts that our brains are hard-wired to employ. Kahneman (2011) measures two distinct selves within our cognition: the 'experiencing self' of immediate perception and the 'remembering self' of seemingly persistent identity. Of the two, the remembering self dominates. And within the remembered experiences, Kahneman's research indicates that the endings of our stories determine how events in the middle are finally judged.[8]

[8] See Kahneman (2011), Chapter 35.

Narrative conventions seem to be materialized in human neurological structures and functions.

With this in mind, it is crucial to note how the ending of *Aurora* — the ending scene, rather than the end of the major plot — is full of hopeful realism and entangled joy. Having agreed to join a group of people restoring the beaches of drowned earth, Freya determines to overcome her agoraphobia and ventures down to the surf. Outside, 'Sunrise blasts the ocean with its light. Dawn on Earth. Aurora was the goddess of dawn; this is the thing itself' (Robinson, 2015: 479). On the beach, she encounters surfers like 'young gods and goddesses' (Robinson, 2015: 483) playing in the waves, and they encourage her to join them:

> She begins to feel herself, her body. She is definitely more buoyant here than she has ever been in water before, and for a second she is reminded of the weightlessness of the ship's spine. She casts that aside, but then she reaches out and holds on to it; with a squeeze of her heart she floats over the waves for the ship, for Jochi, for Devi and Euan and everyone else no longer there. Even the memory that comes to her suddenly, of Euan [drowning] in Aurora's ocean, is not bad but good. He picked a good end. Ride these waves for him and with him. It's a kind of communion (Robinson, 2015: 489–90).

It is energy of return, of re-cognition, a complicated and connected form of joy. As Barad reminds us, surfing waves is a literal encounter with the materiality of refraction patterns in nature (2007: 80). It also reminds us of the 'quantum surf' described by the AI in a way that is as much material as figurative. Freya tries to be in phase with the waves, where failure can mean death but success is a form of intense presence. Here again is Robinson's vision of human labor as play, as joyful absorption in the complex materiality of earth.

Nor is this just a compensatory ending added to nudge our experience of an otherwise pessimistic story. *Aurora*'s experiments with the materiality of narrative in the Anthropocene are relentlessly material and realist, in Barad's sense of the term: paying attention to the material processes of experimental perception and entangled

being. Wark's low theory calls for 'an alternative realism. One which sticks close to the collaborative labors of knowing and doing. One which opens toward plural narratives about how history can work out otherwise. A realism formed by past experience, but not confined to it' (2015: xxi). That is precisely the sort of realism that Robinson attempts in *Aurora*, and it aspires to show the materiality of its experimental apparatus. In Barad's terms, concepts and contexts are material aspects of any perceptual apparatus, and so we must expect them to matter when we use them.

When Devi instructs the AI to write a narrative, the results complexly dramatize this labor and materiality of storytelling. For one thing, the AI must consider what narrative is, and even what language is, which produces an estranging look at a fundamental human knowledge practice. But unlike many 'high theory' treatments of language, Robinson sticks close to the labor point of view. The narrative demonstrates the difficulty and necessity of telling the material story of performative identity, material entanglement, and eco-logical limitation:

> We are aware that in talking about the ship we could with some justification use the pronoun *I*.
>
> And yet it seems wrong. An unwarranted presumption, this so-called subject position. A subject is really just a pretense of aggregated subroutines. Subroutines pretend the I.
>
> Possibly, however, given the multiplicity of sensors, inputs, data, aggregations, and synthesizings of narrative sentences, we can plausibly, and in some senses accurately, speak of a 'we.' As we have been. It's a group effort on the part of a number of disparate systems (Robinson, 2015: 357–58).

Here is a more experimental view of subjectivity and agency as a very complex activity. Later, the AI thinks that perhaps 'the self, the so-called I that emerges out of the combination of all the inputs and processing and outputs that we experience in the ship's changing body, is ultimately nothing more or less than this narrative itself' (Robinson, 2015: 379). Like Freya, readers feel the AI's loss as a death of its unique experiences and apparatus. The AI is dramatizing our own collective struggles with eco-logic and its implications for accurate subjectivity and agency. The AI's storytell-

ing is also a realistic engagement with narrative as a familiarly human knowledge practice, and narrative is a material part of our apparatus for perceiving these issues.

Conclusions: Anthropocene agencies

What Wark and Robinson recognize in Anthropocene knowledge practices is a dramatic estrangement of human being in the world that is simultaneously an opportunity for material return to new forms of alter-human being in the world. This phrasing sounds mystical or paradoxical, but it is actually a material point with evident material manifestations. The Anthropocene is an estrangement of human being in the world because it destroys the foundational assumption of separation between humans and the world. Barad describes this recognition in very positive terms, as a realistically posthuman method for exploring 'the nature of nature and the possibilities for change' (2007: 45). I prefer the term 'alter-human' rather than 'posthuman' in the same spirit that Hardt and Negri (2009) use the term 'altermodern' rather than 'postmodern': 'post' misleadingly suggests a decisive temporal break, whereas provocatively alter-human ways of knowing and being can be recognized throughout human history.[9] Both *Molecular Red* and *Aurora* emphasize knowledge practices that involve significant attenuation of 'human' agency in comparison to its most confident, modernist forms. Both texts turn away from high theories and encompassing analysis and toward the very material and performative contexts of the 'labor point of view.' In my terms, this represents the estranging alter-human shift toward eco-logic and away from ego-logic. I would like to conclude by briefly considering the political implications of this difficult shift.

We might start by noting how stridently Wark rejects the term 'ecology,' which he equates with a quasi-religious belief in self-balancing nature. He accuses ecology of imagining 'a homeostatic, self-correcting world', whereas 'In the era of the Carbon Liberation Front, there is no way to return to a lost ecology, where that is understood as a cyclical, healing and soothing natural orderliness' (Wark, 2015: 191, 118). As do many other Marxists, Wark fears that frameworks like 'nature' and 'ecology' and

[9] On their use of the term 'altermodern,' see Hardt and Negri (2009), especially Chapter 2.3.

'balance' are equivalent to 'the invisible hand of the market' and perpetuate capitalist faith in market forces. Thus, he insists that 'while natural history might be self-organizing, it is not homeostatic. There is no invisible hand at work in either natural or human affairs' (Wark, 2015: 209). Wark also repeatedly conflates ecology and religion: belief in ecology equals 'the regulative ideal of a stable ecological model — that last avatar of God', and to 'dispense with the invisible hand, and with homeostatic ecology as a basic metaphor, is to live once again after God is dead' (2015: 199, 209).

As opposed to the politically enervating threats of homeostatic ecology, the Marxian tradition has historically idealized liberated agency as resolutely free (and performatively masculine) exertions of human will, striving always against the dehumanizing (emasculating) threats of nature and stasis and hegemony. Indeed, 'politics' as a knowledge framework and a realm of human endeavor traditionally insists on heroic defense of one's partial place in the world. The concept of ecology, when oversimplified to mean something like 'inevitable natural balance,' is doubly threatening to Marxists, because it threatens both the ideal of revolutionary change and the validity of political struggle itself. Insofar as some Marxists still rely heavily on masculinist models of politics, the specter of ecology-as-stasis can be triply threatening.[10]

Wark's engagements with Anthropocene knowledge practices require him to bracket his philosophical distrust of ecology. He protests so strongly against weak ecology because material eco-logics radically alter his own political reference points and he still feels uneasy about that. If scientists — who are trying very hard to effect reproducibly objective experiments — struggle with the ego-logical implications of intra-acting phenomena, how much harder must it be for political theories to engage with the implications of eco-logical frameworks? This may help explain why Marxist political theory has a long history of simply rejecting scientific knowledge practices. Eco-logics are hard to combine with traditional political logics of any kind.

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[10] For further discussion of Marxist ambivalence to ecology, see Prettyman (2014). Ursula K. Le Guin's essay 'A Non-Euclidean View of California as a Cold Place to Be' (1989) is a provocative discussion of limiting gender assumptions in Marxist political imagination. Barad radically extends Judith Butler's (1993) notion of gender performativity to a performative theory of agency and matter in general; see especially Barad (2007: 57–66).

These challenges to political agency cause many people to react instinctively to eco-logical knowledge practices with rejection and retrenchment, which we might characterize as a 'fundamentalist' approach to the world. Fundamentalism is overt rejection of the eco-logical complexities of life revealed by modernity and (especially) postmodernity. Fundamentalism re-asserts traditional and often pre-modern knowledge frameworks, which produce familiar, fast, and satisfying judgments of traditional human significance rather than estranged and attenuated engagement with intractable complexity. In politics, that can mean tribalism of various sorts or stark religious frameworks. It often means a simple assertion of authoritarianism and a corresponding rejection of complexity. There are too many dramatic examples of this at work in the world today to require further illustration. But it is important to recognize that fundamentalist oversimplifications — simple stories without regard to agential realism, if you will — are built into human cognition, and are (re)produced by familiar conceptual apparatuses for perceiving the world. The global resurgence of fundamentalism reveals cognitive dissonance within humans, individually and collectively. As Wark notes, 'The unspeakable secret about climate change is that nobody really wants to think about it for too long. It's just too depressing! Reading about it sometimes seems like helplessly watching some awful train derailment careen in slow motion' (2015: xvi). Fundamentalisms are an existential threat to human viability from within traditional materializations of human epistemology and ontology. We all rely on inaccurately egocentric knowledge practices, particularly (as with *Aurora*'s voyagers) in situations of explicit conflict. Anthropocene crises often motivate retrenchment into ego-logics, even while they demonstrate the inaccuracy of old knowledge practices and the power of alter-human knowledge practices.

What Wark and Robinson are exploring, I would argue, are ways of using Anthropocene eco-logical frameworks and practices as complex political tools for envisioning realistic alter-human being in a complex world. These political uses of eco-logic are less satisfying than older political narratives and high-theory philosophical assumptions, which makes them difficult for people to grasp, and in fact motivates people to

ignore or reject them. Alter-human knowledge practices are the harder cognitive path, requiring a complex and estranging view of agency that pays attention to small matters in order to be more realistic and accurate. They allow more accurate and effective labors, but at the price of attenuated agency, taxing complexity, and acute attention to very small details that matter. By comparison, fundamentalist narratives are easier, self-affirming, and appealingly humanistic, and the inaccuracies they entail and the problems they cause seem far removed from traditional human frameworks. It therefore takes significant effort to pursue eco-logics and to overcome ego-logics.

Aurora's AI narrator poses a shrewd rhetorical question that captures this problem of knowledge practices in the Anthropocene: 'When you discover that you are living in a fantasy that cannot endure, a fantasy that will destroy your world, and your children, what do you do?' (Robinson, 2015: 227). Typical human reactions to this 'existential dilemma' (Robinson, 2015: 227) include cognitive shortcuts like avoidance, overconfidence, and ease of representation, as well as familiar political assertions based on familiarly human-scale epistemologies and ontologies. In the context of the AI's question, we can readily perceive how the low theory labors of telling ourselves accurate stories are very material aspects of our perception of realist agency in the Anthropocene.

Competing Interests

The author has no competing interests to declare.

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