Critter Compiler

Helen Pritchard

On March 24, 1989, the oil tanker Exxon Valdez had just entered Alaska's Prince William Sound, after departing the Valdez Marine Terminal full of crude oil. At 12:04 am, the ship struck a reef, tearing open the hull and releasing 11 million gallons of oil into the environment. Initial responses by Exxon and the Alyeska Pipeline Company were insufficient to contain much of the spill, and a storm blew in soon after, spreading the oil widely. Eventually, more than 1,000 miles of coastline were fouled, and hundreds of thousands of animals perished … Though the oil has mostly disappeared from view, many Alaskan beaches remain polluted to this day, crude oil buried just inches below the surface.[1]

The year is 1997 and we are at the Oak Ridge National Laboratory, California. Mike Simpson, the inventor in the lab, is holding up a microchip in front of his computer. He traces the sensor with his finger and points towards the surface; it is here that the genetically engineered Pseudomonas fluorescens HK44 is "living" on the bed of silicon. Mike has fondly named the sensor, a tiny light-sensitive computer chip coated with the bioluminescent bacterium HK44, "Critters on a Chip". When the bacterium encounters petrochemical pollutants, it lights up, creating an electrical signal that the chip can process or amplify. Mike explains that they have used the HK44 to create a biochip as it is sensitive to naphthalene, a common petroleum pollutant. HK44 is a genetically engineered strain that responds to exposure to naphthalene, salicylate and other structural analogs by production of visible light. It was constructed using genes from the light organ of the tropical fish the *Monocentris* and the common bacteria *Escherichia coli (E.coli)*. Exposure to naphthalene, one of the polycyclic aromatic hydrocarbons that are a component of coal and petrochemicals, causes injury to the HK44 and the resulting harm creates a bioluminescencent reaction. Light sensors embedded on the chip subsequently compute this reaction. Mike tells us that a naphthalene biosensor could be useful for monitoring hazardous waste sites, remediating oil spills or as a forensic application to evidence the presence of a particular chemical. The Critter Chips can be installed either on a floating platform or as the patent shows on the backs of the common honeybee. Mike notes that if the bacteria come into contact with polycyclic aromatic hydrocarbons, it flips a biological switch and the bacteria start to glow. As the bacteria used

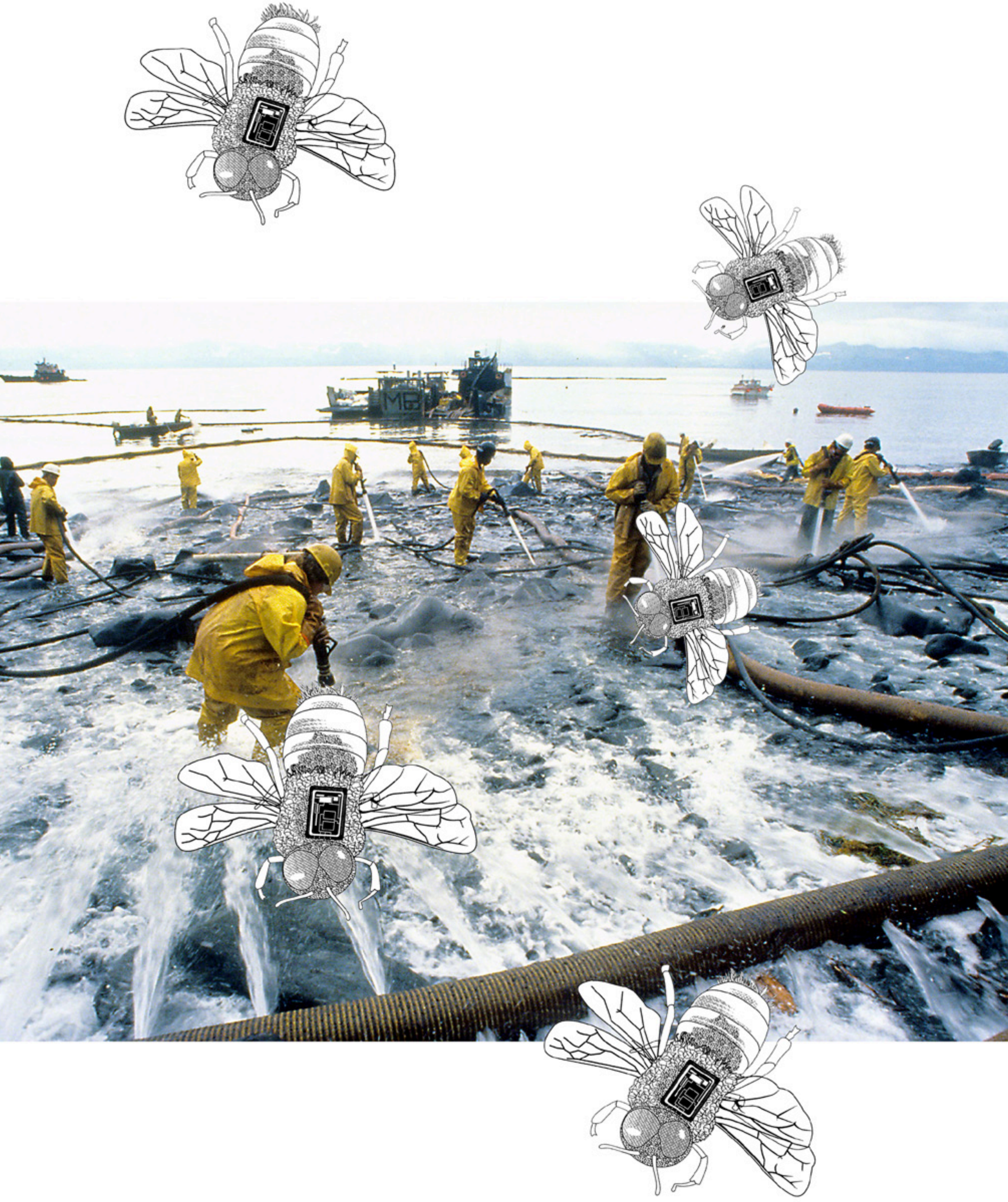

Figure 1. Critter Chips on the backs of Honey Bees, circulate over the Exxon Valdez Oil Spill. Pritchard (2016).

give off a great deal of light, they are able to study the processes at a high resolution—down to a microscopic level in individual organisms. Of course, as he explains — such Critter Chips have limitations, because they are alive. The bacteria and the honey bee hosts need food, and they can die or mutate. So Critter Chips will probably carry (literal) expiration dates. [2]

* * *

This chapter unravels how execution holds — in enduring states — semi-living microbes in sites of petrochemical waste. By referring to semi-living I am not signalling a life sustained through technological means (Catts and Zurr 2002), but a living constrained and held in injured states by computation. I ask what type of activity is this execution that derives from injury and how we might speculate on execution otherwise? Through ethnographic and speculative engagements with Critter Chips I will show how execution can be described as propelling semi-life, outlining how computation exploits the potential of microbial injury and death. I follow this with a discussion of the artwork *Critter Compiler*, a fabulation (Haraway 2013) that engages with contemporary microbial computing. *Critter Compiler* is a prototype for a microbial novella writer and a response to Rosi Braidotti's call for experiments that "are non-profit and actualise the virtual possibilities of an expanded relational self that functions in a nature-culture continuum" (2013, 61). The artwork takes as its starting point toxic execution, and as a speculative experiment performs (or executes) these processes otherwise.

Negative possibilities

In scenes of toxicity, Critter Chips operate through engaging the productive capacities of the HK44. Yet in these scenes this renewal is not often a capacious, co-flourishing, but a drawn out persistence preceding death. The HK44 might be described as a technical component, in which processes of differentiation, in the form of damage or injury to the microbe, signal the presence of toxic hydrocarbons. Critter Chips outline the crucial yet elusive intra-actions (Barad 2007) of nonhuman organisms in computational execution; nonhumans who might be said to accompany execution as negative shapes. As Nigel Clark observes,

> *Our bodies, our identities, our social formations, are also consequent of the non-relation we have with all those who did not make it … Accompanying us as negative shapes — as silent, spectral figures—are the many who did not pass safely across thresholds, who took a wrong turn at a bifurcation,*

> *whose experimental wagers did not win out. Our own flourishing may even be impacted in these falterings.* (Clark 2011, 209)

Microbial deaths become negative shapes that emerge with us from scenes of petrochemical toxicity such as the ongoing pollution from the Exxon Valdez oil spill on the coast of Alaska or the waste from the industry of the Pearl Delta River Basin, in South China. Rosi Braidotti notes that the opportunistic post anthropocentrism of advanced capitalism both invests in and profits from the commodification of all that lives. "The capital it goes after is the informational codes of living matter itself in all its forms. Life, as *bios* as well as *zoe*, is turned into commodities for trade and profit" (Braidotti 2014, 243). It is these processes that not only destroy and erase life but also propel new biotic subjects such as Critter Chips. Whilst advanced capitalism is often characterized by the exploitation and erasure of life, this chapter engages with a contemporary mode of existence[3]— semi-living, exhausted, partial lives that both are propelled into and depleted by scenes of what I call toxic execution.

The existence of Critter Chips is not an individual project, indeed they foreground what Donna Harway and Karen Barad describe as entangled intra-relating (Barad 2007, ix). Critter Chips emerge from an already-meshed-together scene, where their capacities are articulated through computation and particularly execution. Through an engagement with matter, we might understand that it is the excess or creative force (i.e its potential to renew) of both the HK44 and execution that renders the Critter Chips active. Seeking ways to account for this creative force of matter, material feminisms (alternatively called new-materialism or neo-materialism) have often turned their attentions to that of co-creation and conjoined forms of production with the non/inhuman world.[4] Although these accounts have opened spaces of alterity beyond humanist concerns, their search for positive engagements with nonhumans has often attended to only that which we can know and flourish with, rather than that which takes an entity apart from itself. This has led to dominating articulations of life that obscure negative encounters of semi-living, exhausted, partial lives, and as discussed by Claire Colebrook, premises naturalised accounts (2014). Additionally, little attention has been dedicated to the application of (bio)computational organisms in environmental computing, on the assumption that computing that addresses climate change or pollution from petrochemicals is based on an extended intimacy with "nature" and positive possibility. Critter Chips demand us to entertain a different articulation. As Barad notes, "[t]he stakes in denaturalizing nature are not insignificant. Demonstrating nature's queerness, its trans*-embodiment, exposing the monstrous face of nature itself in the undoing of naturalness holds significant political potential"(Barad 2015, 412). In this context it is important to foreground the entangled relations of petrochemicals, waste, computation and capitalism, to trouble nature and its naturalness "all the way down" (Barad 2015, 413), I do this by invigorating the idea of *toxic execution*.

As Wendy Hui Kyong Chun has noted, in the context of computation things always seem to be disappearing in such crucial ways, not just because of the effects of computation but because this process of disappearance is central to the temporality of computation itself. "[O]ur computers execute in unforeseen ways, the future opens to the unexpected. Because of this, any programmed vision will always be inadequate, will always give way to another future" (Chun 2011, 9). Engaging with toxic execution enables us to pay attention to these disappearances so that we might attend to the ways that injury and death are enrolled with the computation of the environment that generates (so-called) real-time (big) data. Consequently, and as a queer experiment, instead of focusing on a co-flourishing of humans and non-humans, I draw on queer theory to pay attention to damage, injury and the constraints placed on the possibilities of life and brought about through computation. As Heather Love notes, there is a genealogy of focusing on injury in queer studies and a willingness to investigate darker aspects of experience (Love 2009, 2). As the anti-social turn in queer theory outlines—to queer something is to engage with both the powerful negativity of punk politics and a mode of crafting alternatives with others (Halberstam 2008, 148 and 154).

I extend queer theories that concern personal injury into more-than-human ensembles in order to consider the damages and attend to the suffering, loving, caring, pain and death shared by humans and nonhumans in entanglements of computation and petrochemicals. Drawing on queer theory is not an anti-affirmative stance. Instead, as Heather Love outlines, "[t]he emphasis on damage in queer studies exists in a state of tension with a related and contrary tendency—the need to resist damage and to affirm queer existence"(Love 2009, 3). Therefore to think through affirmative questions of resistance we first need to ask how execution constrains life and produces an alternative economy of critical life that needs attention. This question pushes us to begin somewhere other than with the economy of life and nonlife.

Trans Practices

Myra Hird observes that nonhumans have long "been overburdened with the task of making sense of human social relations" (2008, 229). Indeed, many critters have been "enrolled" as sentinels in environmental sensing "to detect signs of disturbances that remain indiscernible to humans" (Akrich et al. 2006 cited in Gramaglia

2013). Canaries, molluscs and lichen have all been tasked as sentinels, to signal future events or warn us, "making it possible to lower the threshold for detecting toxins in air, soil and water, and allowing investigations on the effects of low doses of particular pollutants on the environment" (Gramaglia 2013). Gail Davis also points to how our understandings of human corporeality and potentiality are increasingly enacted through the individual bodies of a multitude of laboratory mice (Davis 2013, 3). However, the HK44 has not just been tasked through genetic engineering with the characteristics of a sentinel but also enrolled further as a computational component. Yet as HK44 emit an excited fluorescent glow, as the light from the microscope passes through them, my engagements with them seem to illuminate their enduring liveliness.

In *Animal Trans* Hird describes how she shares Haraway's interest "in trans species/cendence/fusions/gene/genics/national that disturb the hierarchy of taxonomic categories (genus, family, class, order, kingdom) derived from pure, self-contained and self-containing nature" (2008, 231). For Haraway, Hird explains, trans [practices] "cross a culturally salient line between nature and artifice, and they greatly increase the density of all kinds of other traffic on the bridge between what counts as nature and culture" (Haraway 1997, 56 cited in Hird 231). Critter Chips engage me with a trans aesthetics of affective ecologies (such as suffering, loving, caring, pain and death) shared by humans and nonhumans (Puig de la Bellacasa 2010, 8). Provoking an account for our shared "ambiguity/undecidability/indeterminacy" (Barad 2012, 212) in our entanglements with computation. By focusing on Critter Chips, I do not wish to reinstate the categories of the nonhuman organism or execution as fixed. Instead I want to develop a fuller understanding of capitalist practices of computing and the ways in which they extend their reach into the possibilities for life.

Critter Chips

In 1997 "Critters on a Chip" were set to replace expensive and complicated optical detection systems for petrochemicals that used photo multipliers and optical fibres buried in the ground. These Critter Chips used the genetically engineered microorganism HK44 to produce light as it was injured by hazardous waste, so that monitoring could be undertaken at sites of petrochemical accumulation. Almost twenty years later I am a visiting researcher at the Toxicology lab at City University in Hong Kong. China is the third largest producer of petrochemicals, and a site of energetic activity for biotechnology (Ong 2010, 3). Today the lab is busy, and Vincent the lab technician is standing near a rapidly spinning centrifugal machine. He explains that he is generating bacteria for a microbial chip which will detect oil and petrochemical waste from refineries and factories, such as those in the Pearl River Delta, the low-lying area surrounding the Pearl River estuary, where the Pearl River flows into the South China Sea. Today, Vincent is attempting to harvest the genetically engineered bacteria cells that will live on a small microcontroller. He draws a picture for me on the back of his pad, to show how the Critter Chips will shimmer in vast floating networks compiling signals in real-time from the microbes' metabolic and reproductive processes as they respond through injury to oil spills. These signals translate the Critter Chip's injury from toxicity into iterative arithmetic computation. The Critter Chip is imagined in its input/output specification, generating metabolic reactions that produce output quantities of proteins as a function of input quantities of hydrocarbons. Through the process of writing and compiling code in bacteria's DNA it is possible for iterative constructs such as while loops and for loops to be implemented on the Critter Chip, based on a clocking mechanism. The results are mapped onto specific biochemical reactions selected from libraries — a task analogous to *machine language* compilation.[5]

According to Cisco, there will be 50 billion devices connected to the network by 2020.[6] Many of which will be living sensors such as Critter Chips. In Vincent's speculative scene, the Critter Chips are enrolled as part of a networked computational ensemble, producing a fluorescent shimmering glow, to make intense the most harmful, yet unknown, unquantifiable, unrecognizable, unmatchable traces of waste, specifically so they can [re]enter capital circulation as data. I am left to wonder what is brought into play by the "temporal or immaterial dimensions of matter" (Yusoff 2013, 2).

In this spectral vision, as petrochemicals from industry and production circulate, they appear, fleetingly, as glowing traces illuminated by the metabolic process of microbes. The shimmers here are literal and material affective variables, which pattern the flows of polycyclic aromatic hydrocarbons. Whereas the Critter Chips of Oak laboratory were imagined to operate in small independent mesh configurations, the Critter Chips in Vincent's lab will most likely operate in networks, where hub nodes collect and aggregate data using machine-learning algorithms from ensembles of geographically distributed sensors. It is in these sites of computation, which are at the edges of human perception, where much of toxic execution will take place. Lauren Berlant notes, "[q]ueer, socialist/anti-capitalist, and feminist work has all been about multiplying the ways we know that people have lived and can live, so that it would be possible to take up any number of positions during and in life in order to have 'a life'" (Berlant 2011, 182). As I leave the lab that evening and return the next morning I find myself caught within, and approaching, the entanglements of Critter Chips as instruments of difference, arrested within the theoretical metaphors that open up the possibilities of going beyond, discourses of purity and originals, yet also caught within the very different lived experience of the Critter Chips. I am hustling between formations that are metaphorical and formations that are literal.

Continuous Expiration

From the 1930s onwards computation (in technical terms) has on the whole been recognised as the execution of halting Turing machines or their equivalents. Although other models of computation such as recursive functions, rewriting rules and lambda-calculus could have been taken up, the restriction of computation as the execution of a machine that stops or concludes — so called halting machines — takes hold (Denning 2010). This was in part because of material constraints and in part because of what the practices of computing demanded. It was more common than not for algorithms to be terminal, in other words to implement functions, to compute defined values. Critter Chips are however based on interactivity that involves an instantiation of algorithms in the environment rather than a reaching of a resolution. As Parisi notes,

> *[f]rom the standpoint of interaction, the successful running of an algorithm is a performance in the environment (i.e. computation is embedded in the world) and of the environment (i.e. computation needs the world and the data extracted from it to fulfill the algorithmic task).*
> (Parisi 2014, 121)

As interactive processes, the imaginaries and practices that propel Critter Chips demand a different computation to that of a final value. Compared to the Turing machine, Critter Chips take on a different set of characteristics, as they are entanglements of interactive processes, so-called natural information processes, which are imagined as — but not necessarily enacted as — continuous processes. In order to achieve this near continuity, the execution of interactive processes in Critter Chips instantiates itself across computational *and* metabolic processes. The temporality of the termination of these processes is quite different to that of a Turing Machine. The Critter Chip is not designed to perform halting executions that resolve calculations; instead the Critter Chips are (until the expiration date) non-terminating processes in which the fluorescent signals are read by the Chip and sent across the network continuously. Instead of the halting machine reaching a resolved number, in Critter Chips, signals continue until the expiration of the Critter Chips of the microbe, which is a significantly different process.

Petrochemicals have become a focus of increasing concern for human and environmental health over the past two decades. However, the effects of thousands of chemicals still remain unknowable. As Michelle Murphy notes, spatial and temporal industrially produced chemicals, "are regulated and ignored, studied and yet filled with uncertainty" (Murphy 2013, 105). As Vincent and I watch the centrifugal machine spin we discuss how Critter Chips are propelled by this uncertainty. He explains that the advantage of using a Critter Chip instead of an electrochemical sensor is that it is not limited to signaling one chemical of an oil spill but rather, because of the microbes' capacity for injury in response to a wide range of toxins, it is able to further signal the toxicity of a range of known and unknown compounds that are similar to naphthalene. As Vincent demonstrates to me in a petri dish, the Critter Chip is designed to signal the presence of petrochemical compounds that may be unknown, as well as chemicals already defined as petrochemicals. Those that are unknown may remain indeterminate, except for the injury that signals their presence. Rather than determining the presence of a specific chemical, the Critter Chip exhibits affects that can be attributed to toxicity. It is this quality of tracing affects, and existing within the unknowable, that makes the Critter Chip quicker and cheaper than other types of computational sensing.

Through execution across the domains of the biological, geological (fossil fuels) and the technical, the Critter Chip expands the temporal and spatial possibilities for the exchange of information. It could be envisaged that the Critter Chip is an extension of a cybernetic imaginary, one in which microbes are machines, and input and output need not be in the form of numbers or diagrams but sense organs read by ultra rapid computing machines such as imagined by Norbert Weiner (Weiner, 1948, 36). However the Critter Chip is not an ensemble that employs the HK44 because it is the same as the machine but instead because they are different from each other. In *On the Mode of Existence of Technical Objects* Gilbert Simondon outlines a philosophy of technology that pays close attention relationally to "actual difference, techniques, apparatuses and paradigms" (Combes 2013, 89). Simondon's theory of technical objects accounts for the important differences between "living" (humans, nonhuman animals, plants) and technical elements. In part, his focus on difference was a response to cybernetic theories of his time that had undertaken a shift from merely comparing animals with machines analogically, to making the much stronger claim that animals are machines. In cybernetics, these claims of animals as machines were used to envision ensembles of computers and biotic subjects. However for Simondon matter, organism and machine are different, "they can even be said to be ontologically different, but within an ontology that methodologically avoids dualism and substantialism" (LaMarre 2013, 80). It is under these circumstances that I want to suggest that the instantiation of computation across metabolic processes is more akin to the "enhancement" of the machine through differentiation that enables an increase in sensitivity to information, as opposed to a cybernetic model. Simondon outlines extending the margins of indeterminacy in the technological ensemble, noting "[i]t is such a margin that allows for the machine's sensitivity to outside information. It is this sensitivity to information on the part of machines, much more than any increase in automatism that makes possible a technical ensemble" (Simondon 1958, 13). However Critter Chips are by no means what Simondon describes as an open machine with freedom of operation.[7] Instead the Critter Chip only increases the margin of indeterminacy at critical moments in its operations, and at other points the meshing of organism and chip restricts the margin. It is the restriction that holds the HK44 in its enduring state and enables a certain level of performance as a sensor. It is this double bind that is exploited in the Critter Chip ensemble and renders the HK44 semi-living. The microbial processes of the HK44 open up the sensitivity of the technological ensemble yet are also moments of injury. The practices of computation command that the HK44 are genetically engineered around its ability to temporally localise its indeterminacy at critical moments in the computational process, such as its ability to shimmer in the presence of toxicity. At other critical moments, HK44 has to be able to do less, to live less, in order to remain enduring, that is to be more component like and less life like within the technical ensemble. Under the glare of advanced capitalism in which nature, commerce and politics are explicitly entangled, the use of HK44 to extend the margins of indeterminacy points to the ways in which toxicity "straddles the boundaries of life and non life as well as the literal bounds of bodies in ways that introduce a certain complexity of integrity of either lively or deathly subjects" (Chen 2012, 4096).

Through extension into biotic subjects, toxic execution (both applied and speculative) extends the horizon of calculation to include protein production, metabolisms and nonhuman variation. Yet it is the same innovative capacities that have the potential to extend calculation that also limit the HK44 to life lived for the Critter Chip, constraining its possibilities for life. As Steven Shaviro (after Whitehead) notes, life cannot be understood as a matter of continuity or endurance, "[r]ather an entitiy is alive precisely to the extent that it envisions difference and thereby strives for something other than the mere continuation of what it already is"(Shaviro 2010, 113).

Enduring States

The primary feature of toxic execution is not generalised interactions that lead to some kind of fusion of all that there is, or a mass entanglement or the biological, geological and technical. On the contrary, the microbial organisms that toxic execution acts upon hold together in a specific mode of advanced capitalism in which they are not independent of a complex environment they partly shape, and upon which they depend, but is also constantly putting them at risk (Stengers 2006, 8). Specifically, toxic execution holds together in a way that generates value through its entanglements with petrochemicals, humans, nonhumans and the network. If, as Jennifer Gabrys notes, "[w]aste reveals the economies of value within digital technology" (Gabrys 2011, 17), toxic execution highlights the reclaiming of waste as producing value in computation. This value from human labour is inseparable from toxicity and critter chips. Mazen Labban outlines (in relation to microbial biotechnologies for fossil fuel extraction), that these processes produce "what neither can on its own". This specific mode is a generation of capital from a wasting, "through which value is simultaneously created and reproduced, transferred and preserved, and extracted from waste and transformed into other forms of waste" (Labban 2014). Yet this injury is a double bond as it is the process by which the Critter Chip also persists. The constraint of both humans and nonhumans affected by toxic execution is most violently revealed in these states of suspension and liminality that Critter Chips are held in, violence that remains unaccounted for, in exchange for the hope of the predictive capacities of big data and intimacies with the environment. Thinking with toxicity, we can recognise that there is not a computational network that constitutes a technological outside to ecological life. Rather, toxic execution is the force that emerges from the collapse of subjects through their intra-actions with computation. What seems important to retain is a fine sensitivity to the intersectional sites in which computation and petrochemicals involve themselves in very different lived (or partially lived) experiences. In the experience of the Critter Chip, the HK44 are not rendered as unproductive or dead immediately, but are held in a state of enduring productivity, by harnessing the affects of toxins as something quantifiable by computation. They become productive (more productive than a query run across a central processing unit), if only for a moment in a short-lived life. Computation in this scene brings back into circulation all perceived wastes, which include toxic and queer subjects through their enrolment into productive roles.

Critter Chips are scenes, in which computational execution is increasingly instantiated (in both a metaphysical and computational sense) by the extension of computation into nonhuman organisms.

That is, the bodies of nonhumans with carbon-based metabolisms emerge solely as entities to contain the execution which seeks to compile the innovativeness of organisms. This is not however another example of the parasitism of life by capital, but an engineering of, and extension of, vulnerability to execution.

In the twenty-first century, Critter Chips emerge as part of a computational ensemble engineered to instantiate the formal rule of algorithms, with injury becoming a significant component of sensing. Critter Chips bring to the fore the ways in which advanced capitalism plugs organisms into systems of (big) data at the service of capital. Consequently it is from sustaining injury and prolonged death (rather than the exploitation of life) that capital extracts value. In doing so, toxic execution acts as a quantum torque simultaneously tightening and loosening on life.

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Critter Compiler

How then might we speculate on ensembles of microbial organisms and computation otherwise? In the Critter Chip the HK44 exists for its capacity for injury. However as Lynn Margulis evidenced, microbial life played a unique role in establishing the biosphere and have a continued prominence in earth processes and signaling climate change (Margulis 1998; Hird 2009; Clark 2011). So then how might we open up the processes of execution to a freer relation with the amazing deeds of microbes? That is to enable microbes to exploit execution as manifestations of life and to "generate novel forms and behaviors, probe new pathways and spaced of possibility, proliferate itself" (Clark 2011, 42).

Critter Compiler is an experiment, a speculative artwork developed as a response to microbial computing otherwise, through a more unruly process of compilation. *Critter Compiler* exploits the heat generated by execution of a recurrent neural network to train a novella writing algorithm, which in turn provides the heat needed for algae to proliferate. As computation is executed the central processing unit (CPU) processes much of the activity that takes place in the computer—and as this happens, heat is emitted, to the point that the execution processes can cause the CPU to overheat or burst into flames. Recursively, as the algae pass over the CPU it cools it, affecting its processing speed, which in turn effects both the algae growth and the novel-writing process.

Whereas Critter Chips are harnessed in semi-living states to signal toxicity, *Critter Compiler* is an unruly multitude of algae microbes and computational processes. Critter Chips are always-already proceeding towards harm for capital. Instead, and as a form of punk solidarity, *Critter Compiler* enlists the process of execution to promote unruly growth of microbial life. Yet although this is a fabulation, just as "the vast majority of microbial intra-actions have nothing to do with humans" (Hird 2009, 2), much of the processes of *Critter Compiler* are similarly inaccessible to us. Instead of approaching microbial life as a resource to measure and extract data from, *Critter Compiler* is an engagement with processes of execution that attempts to generate a non-profit-oriented experiment.

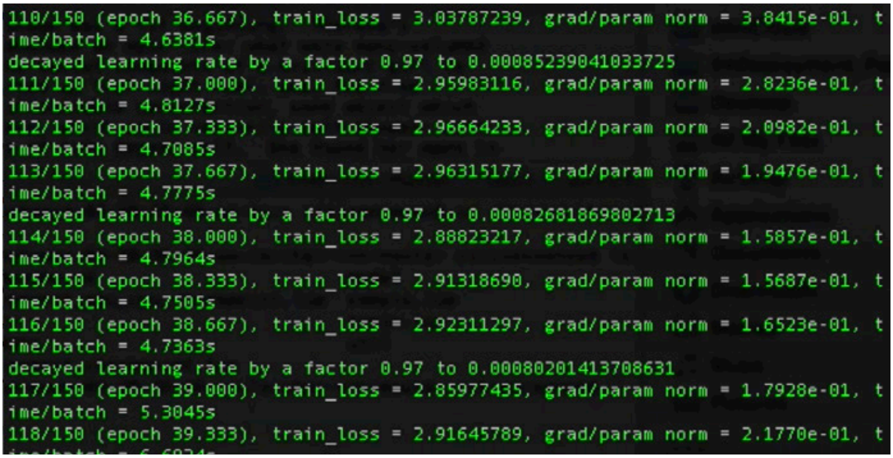

Figure 2. Critter Compiler in training. Pritchard (2016

In the case of the *Critter Compiler*, the machine learning algorithm learns its writing style at a character-based level from George Eliot's vast novel, *Middlemarch* (1871-72), which is both "A Study of Provincial Life" and a meditation on social and political justice. Therefore, whilst some machine learning algorithms might have been trained for efficiency, financialisation, attention on individuals and profit, *Critter Compiler* is trained by a novel that conveys how we live in a world in which we are all bound in a huge web—and if one pulls one way or another someone or something is affected. Consequently, in *Middlemarch* all events, even the smallest or most everyday ones, are connected to planetary flows—much like microbial life. In addition in *Critter Compiler* the characters are not all human, and their genders are not fixed. In our algorithm, algae species and other lively nonhumans replace human characters. The audience-participant is a witness to this story, which unfolds between us, aquaspheres, politics, global climate change, and algae. Starting at the genealogy of injury but not lingering there, *Critter Compiler* is a small experiment in practices of execution that contributes a set of possible ethno-political practices for microbial computing and life itself, while resisting the production of ever new reparative fantasies of ecological life within networks.

Notes

1. http://www.theatlantic.com/photo/2014/03/the-exxon-valdez-oil-spill-25-years-ago-today/100703/.

2. This is a semi-fictional account based on archival research, patent research and my own lab research in 2013.

3. For a further discussion see the panel convened with Elizabeth R. Johnson "Bioaccumulation: Re-valuing life in the Anthropocene", Association of American Geographers (AAG) Annual Meeting, San Francisco , 2016 and https://www.jiscmail.ac.uk/cgi-bin/webadmin?A2=CRIT-GEOG-FORUM;27909dfd.1509. Thanks are also due to Kathryn Yusoff, Johnson and Mazen Labban for their feedback on my paper presented on this panel.

4. For example Haraway's exquisite story of meeting, feeling and listening together during agility training with Cayenne (2007); or Eva Hayward's evocative engagements with cup corals, that explore multispecies sensorial ensembles and unruly provocations (2010).

5. See Shea et al. (2010) for a discussion on the modularization and abstraction of synthetic biology.

6.http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf.

7. For a parallel discussion that pays close attention to the widening of the margin of indeterminacy as an intervention that might enable greater freedoms of operation in technical ensembles see Jennifer Gabrys's eloquent account in Program Earth (Gabrys 2016, 256–258).

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