Ant Network Theory

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Because SF is a thought experiment and engages in worldbuilding, this paper is a hybrid faction piece that presents a history of ants in SF (across texts and media) as one connected narrative, while working through this history as an insertion into Nature-Culture debates through the production of new SF. In constructing SF worlds, writers work with what is called the genre mega-text:[1] the tropes and themes that constitute the identity of the genre. For SF however, this mega-text also involves a cluster of associations from other forms and kinds of texts, including scientific speculation, anthropological theory, STS, among others. The main storyline is based on several fiction and film pieces that structure the enquiry, from early works by H. G. Wells and Premendra Mitra, to Big Bug films, to new SF from the 21st century. The stories can be read as standalone pieces, yet we hope that the reader will read the endnotes, picking up the references which provide a glimpse into our strategies of worlding. The speakers in the endnotes are two time-travelling scholars writing from an unspecified far future, at a time when other beings rule the planet. They are using references from STS scholarship and SF that are more familiar, from our own time, in order to speak to us, even if the necessity to traverse multiple temporalities through simple language to express the Ant Network Theory (ANT) on occasion produces spatiotemporal anomalies.

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In the Beginning

The beamplay was deriving equations from the sensor data on the box when Dr. Vy had to pick them both up and head out hurriedly for the conference, leaving a cup of Soylent. [2] The tiny pinprick from the wrist alarm came while Vy was still poring over some last-minute notes, and there was little to be done after that. One must move with the clock or not at all. The Assisted Evolution[3] conference[4] was a make or break. Now in its 35th year, it annually attracted arguably the wildest group of researchers out there, thinkers of new futures, who presented probable and speculative models of mapping evolution in biological and other beings.[5] This was the third year that Vy had attended this conference. The previous times, their motive had been to understand whether the audience

And Then …

Intominne 7f1ae5pl9 saw with satisfaction that the plate module had finally come to life. It was, they knew, an old-fashioned archive of irrelevant sequential memory narrative,[32] but as trail keeper, their job was to locate and fix these in order to make sense of prehistory, a time when some organisms still believed in time.[33]

This one was all an auditory message, and 7f1ae5pl9's pathways transferred it through the hectoplates[34] on their body to section c98, one of the 8 cells of their body where encrypted auditory information was generally processed. The first information set was about the flying creatures once again, similar to the other plate module they had recovered underground a day ago. There was a memory

… Toward the Beginning

We knew they would take over, eventually. The conditions were ripe.[43] After our two invasions into their realm were unsuccessful, we simply had no means to continue the fight.[44]

Why are we wasting our time here then, observing them?

Gathering intelligence, my friend.

I know that, but my question is why. We are not planning to try again I hope. It might be catastrophic. We have the capsule. Let us release it and be done.

was receptive enough to controversial ideas, and finally Vy was confident that there would at least be some who might take the project seriously, and perhaps be generous enough to fund further investigation. Many attendees were synths, humans who were attuned to technomodification of the biological species, having received new features to match their sociopersonal desires.[6] There were the Swarm Intelligence folks, [7] socialists who believed in cybergence for human survival.[8] Vy knew this audience, and they were the ones that needed to be convinced of the plan.

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The audience let out an admiring gasp when the scope focused on the tiny insects and blew up their image on all the beamplays. The ants had all been tagged and attached with a nanoarray[9] that modulated and disrupted the

of something called a crow, which seemed to be a strange sort of message carrier, transmitting messages about forthcoming messages between individual human units.[35] There was a more pleasing memory too, of something called a stork, which seemed to be a birthing carrier of sorts in prehistory, transferring human fetuses or newborns—it was not clear which—from one geographical area to another.

The second information set had details about rudimentary non-autonomous machines, but they did not seem to be hybrids, which was the object of their enquiry.

The third information set was something of a holy grail for biologists, since it gave a human source for the Out of South America theory of ant origins;[36] but in the end it did not contribute to their quest.

I don't know about you, I am here because I enjoy their company. They are so individual, so insignificant. Almost friendly.

They are a form of life. Adaptable too. We should have let them be. I don't understand why interfering with evolution is not colonization.[45]

Yeah. But this is so they will connect with us, eventually. Not now. They will be too busy evolving, but in some far future. After all, this is just phase 22.[46]

What do you mean?

I am not sure this is the right approach, but we will do it anyway. This is just protection. It's the mission.[47]

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pheromone signals[10] and as a first step Vy was demonstrating how ant behavior could be regulated by such modulation. But the fun really began when Vy began to release other ant species, then spiders, and then other smaller insects into the mix, and finally a pair of hungry lizards, all bearing nanoarrays, and equally susceptible to new functions.[11] Through constant modulation, Vy made them work with each other; indeed collaboration rather than competition was the desired end result.[12]

Observe, Vy said, that these different species of ants and these other insects are operating in the same environment, fighting for the same resources—indeed, they are mortal enemies of each other left on their own.[13] But it is possible to arrange them in such a fashion that instead of functioning as discrete species and organisms, they operate as one organism,

It was in the fourth information set that they found new information that they were looking for. This one seemed to be a starmap, and a record of beyondplanet flight. While the map was extremely basic, and contained no information 7f1ae5pl9 could not see with their own eyes, the spaceflight records showed that the Hybrid0s were scheduled to launch 21 beyondplanets with living and non-living hybrid (Hybrid 1-21) information.[37] So far, they had managed to locate only 19 such sites, and there was an open debate about prehistory between Intominne and Sritees[38] on the possible number of beyondplanets. Since each module contained one complete hybrid makeup, the number of modules hypothetically determined possible habitable colonial zones.[39]

GSP[48] Abiogenesis Pod 3720 released.[49]

each benefitting from and working with and for the other, and themselves.[14] They can even consume each other, should it be necessary for the survival of the whole, but no part of the whole is privileged over another.

Of course, different species have always worked with each other in symbiotic relationships. What I have done differently here is a two-step modification, in which the individual insects are responding to different signals—but even more importantly, they are responding to those signals because they have been modified to respond to do so. In other words, the nanoarrays are transforming them continually into hybrid beings whose survival depends on coexistence:[15] they are not different species but different parts of the same network, a body of bodies, a being of beings, a superbeing [16] if you will, that can bypass taxonomic ranks.[17] If we add other

7f1ae5pl9 was just about to get started when the storm warning pricked sensor 21128122632. They got up with their six supporting legs, took seventeen steps, and dived back into the ocean.[40]

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The mystery of the missing two species occupied the Intominne and Sritees at their next seven information exchanges. After the discovery of the Sector219 plate module, they had managed to recover seventeen more related plate modules which showed evidence of 21. However, there must have been some problem with beyondplanet flight at this stage, because it seemed that the last two had been canceled and the Hybrid20-21 were made redundant. The 983 module information set 6d offered them the tantalizing possibility that the two final ones had not been fully mobile

species or other beings into the mix, the self-programming nanoarrays will arrange themselves according to the context.

What I am proposing is that we can think of assisted evolution differently. I call this the ANT: the Ant Network Theory.[18] Like ants, we do not seek to become or create a hivemind, but to embrace a form of collective multispecies intelligence.[19] In this approach, the species is no longer the object of modification,[20] but what we concern ourselves with is the coevolution of whole sets of species.[21] Instead of thinking in terms of long-term evolutionary grips for the development of true human-like intelligence across all biological and non-biological life, we are creating short-term grips, agglomerates of biological and non-biological life.[22] The agglomerates can be self-sustaining as long as they function together, and create sufficient

species, but enhanced green-blue hybrids, which was not surprising given that the green-blues were among the few types that could have survived the ice-melt of the 25th era. It referred to the location Uruguay, an underwater site in Sector887 that had not been fully explored, but where the two final hybrids had been abandoned.

Since Sritees held the opinion that current beings were the descendants of species that had originally been located in sectors 750-897, and given they must have been at least partly blue on account of their underwater ability, this necessitated exploration of Sector887. Perhaps this was the missing site, which could complete their pre-hybrid archaeology.

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resources to eventually merge with more dominant species or technologies and exhibit true collective intelligence. [23]

In other words, Vy spoke in a steady but emphatic tone, what we have here is a radical solution to the last extinction,[24] a welcoming, if you will, of the alter-technobiological into our own being.

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So you managed to surprise them after all, Mandula said as they bought beers to end another hectic day. The hotel bar was open until late, which was a relief, and almost all late evening sessions upstairs led there, according to some unwritten conference law.

Don't really know why though, Vy said. It's not like we are the first to suggest that this

It was green: thoroughly, totally green. But within the green lay veins of blue, a complex filtration system that illumined the water as it passed through the green. It was water within and water without,[41] the former a dark and occasionally fetid mess and the other a lighter h2o but charged with femtoparticles that moved constantly in the vein stream. Further research revealed the possibility that the green system extended, like a mesh, through all the sectors of the planet, indeed, it covered the surface area of all the planet itself on many different layers. As for the femtoparticles, when any of the veins were opened, they ejected, dispersed and became invisible, and the vein closed again.

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As of the 37th era, the hypothesis exists that hybrids 20 and 21 are a unique large-scale

might be possible, especially after we gave up South America.[25]

Hypothesis versus demonstration...Cheers!

It is an ambitious plan. If it works—and it just might, then the future will indeed be very different for both our species, and many others as well. They said the ants were already ready to be synced. But frankly, I am thinking of this as a step towards collective superintelligence.[26] The more successful the integration, the more flexible the superorganisms, and the more diversified their function. Each unit both individual and more than the sum of its parts. A post-speciesist intelligence.[27] If we are to break the cycle of futile destruction, we must be able to find a way to coexist with beings and objects irrespective of our similarities or differences with them. Find a way to think together.[28]

stigmergy between life and non-life, with the planet surface (species 20) a living hybrid that was the cause of the other lifeforms: a mother organism. The femtoparticles (species 21) are thought to be a second, non-living hybrid that exists within and through the first, a filtration system serving as an abiogenetic seed that spreads itself through the ocean surfaces of the drowned world. The first produces differentiation amongst existing hybrids, the second produces new hybrids. It is also thought that the planetary hybrids themselves comprise the macro-geoengineers of the planet as well as the geological features themselves.[42]

The problem of scale inhibits further research, for now.

You spend too much time with the ants.
Mandula[29] laughed.

Ants aren't a hivemind, but I get your point. [30]
Without learning from them I wouldn't have
been able to achieve any of this.

They had not noticed that the small, thin,
figure had come so close to them, and were
both startled when the black synth hand
introduced itself into the conversation with a
card. The black ears were equally
unmistakable.[31] "A pleasure to get a chance to
catch you, Dr. Vy. I am RDOvx9, and I
represent the Pacific eVolution Collective.
May I have a moment?"

Appendix XII: The ANT manifesto

The following are the recovered principles of ANT

1. That there is no Nature-Culture (NC) divide
    a. C exists as a system of interpretations of N

   b. The technological is simultaneously N and C
      i. We have always been cyborg
      ii. We have always been many
   c. Assisted Evolution is not a movement from N->C, but N->N
2. All evolution is assisted evolution
   a. Evolution is not internal to the organism itself, but is a planetary phenomenon
   b. Evolution is hybridization consisting of the differentiation and production of networks
3. Hybridity is central in the understanding of networks
   a. A multispecies approach is step 1 in the understanding of hybridity
   b. A network approach is step 1 in the understanding of distributed collective intelligence
4. Distributed Collective Intelligence is the Ant Network
   a. The Ant Network provides the basis for planetarity
   b. Since we are planetary the rights of the non-living must be considered
   c. Traces of the non-living and the not-yet-living are the pheromone trail for Ant Network Theory

[1] The term "mega-text" is used among others by the Australian critic Damien Broderick (1995: 61) to define the characteristics that different works of a genre relate to, and which readers and audience can readily identify: "a collective intertextuality."

[2] Soylent is an energy and protein drink, targeted for computer programmers—enabling them to stay at their stations and not break (unnecessarily) for eating and for social discourse. The vision is the worker becoming one with their machines (echoing David Rorvik's (1971) *As Man Becomes Machine*). Soylent is particularly suitable for the goals of the lifehacking community (see Reagle 2019). We see in the film *Them!* (Dir.

Gordon Douglas. 1954) that while the ants are like people (they act singly or in small groups), humans react to them as hive members. This relationship between the ant, the human, and the machine is interesting to unpack. Computer search algorithms (such as Ant Colony Optimization) are based on how ants communicate (see Dorigo and Stutzle 2004). The essential argument is that ants can be faster than supercomputers in sorting out difficult procedures such as the traveling salesman problem—whereby one tries to calculate with maximal efficiency the most efficient route a salesman should take between multiple points. They work by adopting an analogy of the ants' pheromone trails, which tell ants proximity (by the strength of the scent) and size (by the number of trails) of a given food source. By leaving traces, 'dumb' ants can produce intelligent solutions. More generally, it could be said that computing devices are creating trails which we follow blindly (see Schüll 2016 on nudge technologies) so that humans are communicating more and more as ants do. The term soylent is famously associated with the SF film *Soylent Green* (Dir. Richard Fleischer. 1973), an overpopulation dystopia, in which human beings are recycled and turned into food. The film is in turn based on Harry Harrison's (1966) *Make Room! Make Room!*, but significantly diverges from the novel, in that in the original soylent is simply soya and lentils.

[3] Assisted evolution is a key theme in the contemporary ecological discourse, standing in for human intervention into the non-human worlds in order to accelerate the evolution of other species to enable them to survive anthropogenic climate change. An example of such intervention is the Australian Institute of Marine Science's effort to preserve the Great Barrier Reef corals (see: https://www.aims.gov.au/reef-recovery/assisted-evolution; accessed 19 April 2019). But assisted evolution can also be read as a byproduct of the artificial evolution discourse, which has a longer and more problematic history in SF connected to eugenics. Olaf Stapledon's (1930) *Last and First Men* stands as the prime exemplar of this trend in the first half of the 20th century, and Octavia Butler's *Lillith's Brood* (Xenogenesis series) (1987-89) is the most important example in the second half. In more recent times, transhumanism has taken on some related ideas to promote accelerated evolution of humankind (for a succinct summary, see Lilley 2013). We draw attention to assisted evolution as a recurring theme in SF, especially as it relates to the imagined evolution of non-human species such as the species of ants in the works we discuss, starting with early novels such as H. G. Wells' (1904) *The Food of the Gods and How It Came to Earth*. Assisted evolution is usually seen as a problem in SF, the notable exceptions being pro-transhumanist texts, which, however, privilege human evolution at the cost of everything else. In our story, an Advaita-inspired thought experiment, we work with the co-evolution of multiple species but also technological forms, trying to imagine *co-futurity* rather than single evolutions of any species such as Transhumanism tries to do, such that any vestige of dualist thought (being-non-being, human-nonhuman, life-non-life, nature-culture) can be discarded.

[4] This gives some hint of the dating internal to this story—the first 'Assisted Evolution' conference was held at Santa Fe Institute, New Mexico in September 2151. The keynote address was by Geoffrey West (age: 211), whose work on scale did so much to smooth the way for envisioning intelligent ants by analyzing scale invariant properties of communication systems. Assisted evolution is also the core concept in Andrei Tchaikovsky's (2015) *Children of Time*. Although spiders—rather than ants, who are turned into a mindless servant species despite having

displayed collective intelligence—are the main beneficiaries, the principle is the same. The spiders are prey to an 'arachnomorphic' view of the world, just as humans at that time were inclined to anthropomorphism (Tchaikovsky 2015: 52).

[5] The first evolutionary computer was imagined by the cybernetician Gordon Pask in the 1960s. Circuits would compete for electricity—getting rewarded for correct results and starved for bad ones (cf. Miller and Downing 2002).

[6] Here, we are again reflecting upon transhumanist evolutionary discourse, such as is often found in hard SF, which considers human evolution as the paramount technofuturist goal, for instance Greg Egan's (1997) *Diaspora*, but is often less interested in the evolution of other forms of life. Uploading, for instance, is seen as one such strategy of evolution.

[7] The Borg in *Star Trek* are a well-known SF example. Ants are often the example given of a form of swarm intelligence. They operate according to a few simple rules yet appear to act intelligently in the environment—constructing huge, ramified colonies; knowing when to forage and when to defend; finding the fast paths to a food source (cf. Hölldobler and Wilson 1990). A core concept here —one central to the development of Ant Network Theory is stigmergy: entities communicating with each other through leaving traces in an environment. Ant search strategies use notional pheromone trails to do this work. The basic principle of stigmergy is simple: traces left and modifications made by individuals in their environment may feed-back on them: "The colony records its activity in part in the physical environment and uses this record to organize collective behavior. Various forms of storage are used: gradients of pheromones, material structures (impregnated or not by chemical compounds), or spatial distribution of colony elements. Such structures materialize the dynamics of the colony's collective behavior and constrain the behavior of individuals through a feedback loop" (Theraulaz and Bonabeau 1999: 111).

[8] Swarms are often contrasted with or compared favorably to crowds, which are seen as less intelligent (See Rosenberg *et al* 2016). In SF, the laws of Asimovian psychohistory are a form of the latter—while the behavior of individual humans cannot be predicted, the behavior of groups are understood to be predictable, which makes history itself predictable. The crowd model thus reduces individual intelligence to group/mob behavior, and thus, instead of making the future a realm of unfolding possibility, makes the future predictable, just as the swarm model makes the individual predictable and emergent effects the realm of possibility. Charles Elkins (1976) thus famously identified Asimov's psychohistory as a form of vulgar Marxism. However, Asimov also moved away from the crowd model and towards the swarm, co-evolution, and Gaia in the final books of his *Foundation* series, written over 30 years after the original books. We make this distinction to point out that there is an evolution to how SF as a field itself imagines the evolution of humans and other species, which parallels and is coextensive with societal understandings of species behavior (cf. Chattopadhyay 2018).

[9] Nanotechnology is everywhere, a scale of miniaturization that makes ants look huge by comparison, but here we are referring to another foundational text of transhumanism, Eric Drexler's (1986) *Engines of Creation*, and its idea of self-organizing and replicating nanobots. Robert

Charles Wilson's (2005, 2007, 2011) *Spin* trilogy explores a universe colonized by mindless nanobots, which maintain human life across the universe so they can 'feed' on their complexity.

[10] We often use the environment as a memory system. Maurice Halbwachs (1992) gave the layout of a village, or the Stations of the Cross in a church as examples—we don't need to remember civic order or the stations. In a classic of organization theory, James P. Walsh and Gerardo Rivera Ungson (1991) discussed the consignation of memories to files, to office layout, to temporary heaps left on the floor by the door to remind you to do something on the way home to other organizations (which you know will prompt you, for example when a bill is due). Memory is a highly distributed, collective phenomenon —another basic tenet of Ant Network Theory.

[11] Again, *Children of Time* is a reference for the interaction with other species. The British naturalist Alfred Russel Wallace discovered the 'farming' of a fungus by leafcutter ants. "Next to humans, leafcutter ants form the largest and most complex animal societies on Earth. In a few years, the central mound of their underground nests can grow to more than 30 m (98 ft) across, with smaller, radiating mounds extending out to a radius of 80 m (260 ft), taking up 30 to 600 m2 (320 to 6,460 sq ft) and containing eight million individuals" (https://en.wikipedia.org/wiki/Leafcutter_ant). In a further computer connection (see note 7 above), a leafcutter ant with fungus is used as the cover for a book on blockchain (Bashi 2018). With the promise of order without centralized control, the book heralds a future of distributed autonomous agents (much like ants) who will make our decisions for us.

[12] We are referring to mutualistic symbiosis here. A well-known example in SF are the trill from the *Star Trek* universe, where the humanoid host is able to draw upon the memories of the symbiont. Animalling from Lauren Beukes' (2010) *Zoo City* provides a more recent example, with the creature being both burden and power for the host. However, not all symbioses are as advantageous to the host, and they have been a traditional theme for alien invasion narratives, such as Robert A. Heinlein's (1951) *The Puppet Masters*.

[13] Ant species often fight, and invade the colonies of each other, a classic example being the Amazon ant. Ants also take over other ant territories. Globally, red ants have invaded all continents over the past few hundred years (see the fascinating description in Giraud, Pedersen and Keller (2002)). They can furthermore develop single colonies thousands of kilometers wide —meaning that ants over that entire range will not see themselves as separate colonies and will not attack each other. There are two basic theories for this: genetic cleansing (it was largely a way of getting a social innovation to get more productive workers) or there was a 'bottleneck' as they were leaving Argentina to move into the North American continent, so that more colonies were thrown closer together, which led to a selection for friendliness (recognizing related colonies as enemies was suicidal in the compass of a restricted area).

[14] In the movie *Phase IV* (Dir. Saul Bass. 1974), one of the major ant texts sitting in the background of our thought experiment, different ant species have co-evolved to cooperate, and that is what makes them a threat to humans. Both *Phase IV* and *Them!* present long infodumps narrating the coordination and cooperation of ant species.

[15] Coexistence: one of our main arguments is that evolution is driven by competition *and cooperation*. In this model, while different species retain their individuality, they also cooperate, following the *traces* of other planetary inhabitants, living, non-living, and the not-yet-living. These traces are like the pheromones of the ants, at once necessary for survival and operating as a network for knowledge production. The trace of ancient lifeforms lies in our plastic, since it is made from fossil fuels, just as the use of plastic leaves traces in newer geological objects such as the plastiglomerate, "an indurated, multi-composite material made hard by agglutination of rock and molten plastic. This material is subdivided into an in situ type, in which plastic is adhered to rock outcrops, and a clastic type, in which combinations of basalt, coral, shells, and local woody debris are cemented with grains of sand in a plastic matrix" (Corcoran, Moore and Jazvac 2014: 5). Thus, vital processes of the living constitute - and are constituted by - the vitality of the non-living, and vice versa.

[16] This dream of a superbeing extends the concept of the singularity sometimes expressed as humans getting swallowed up by, or into, machines. The latter is a common SF trope —most beautifully developed in John C. Wright's (2002, 2003a, 2003b) *Golden Oecumene* trilogy. Creating superbeings down the taxonomic hierarchy as well as up to the divine. A common trope of the singularity is that intelligent machines are the next step in evolution (cf. Shanahan 2015, and assorted comments by Stephen Hawking, Bill Gates and Elon Musk)). Interestingly, this often ends up by completely shedding flesh and blood: "Roboticist Hans Moravec anticipates a far future in which a portion of the universe is 'rapidly transformed into a cyberspace, [wherein beings] establish, extend, and defend identities as patterns of information flow … becoming finally a bubble of Mind expanding at near lightspeed'" (Shanahan, 2015: 157). The singularity lies between present dreams of the servitude of machines ("then it will become feasible for machines to carry out such jobs and to do so more cheaply and more effectively than humans (as long as they can be treated as slaves with moral impunity)") (Shanahan, 2015: 152-3) to future visions of our servitude—it seems to be slaves all the way down and all the way up.

[17] One such creature is imagined by Kathleen Goonan (2016) in her short drowned-world biopunk "Who Do You Love?", which depicts the future evolution of a human-fish-animal hybrid able to survive in water. While the story does not quite take place in what we might call "posthomic time" following Dougal Dixon (1981), we argue that these hybrids, instances of co-evolution, like Wellsian crab monsters at planetary end-times, are more likely than humans to reach that time.

[18] ANT has much in common with the earlier actor-network theory, which posited agency as a feature of the network of humans and non-humans rather than as the prerogative of humans (an ant-based analogy would be the relationship between leafcutter ants and the fungus they farmed—there was no reason to impute agency to the ant alone). In its earliest instantiation, Actor-Network Theory was still modeled on a

superman imposing his will (cf. Amsterdamska's (1990) critique); in later years, emergence came to the fore. Tim Ingold (2008), who pitted the relatively solitary spider with its web against the collective ant (much as Tchaikovsky does in the *Children of Time*) is interesting in this regard. His dialogue between the ant and the spider revolves around the issue of agency—the spider recognized hybrid formations (web plus spider; ant plus aphid) but wanted to privilege the organic over the non-organic with respect to the principle of agency. This traditional critique of actor-network theory does not apply to ANT, which recognizes that agency can be attached to any kind of actant. While actor-network theory did in principle treat all actants symmetrically, this often was honored more in the breach than in the observance when it came to dealing with the thorny issue of agency. Both actor-network theorists and their sly detractors unduly privileged the (human or nonhuman) actant at the expensive of the wider environment. This was an act of 'misplaced concreteness' (Whitehead 1992: 52): the theory often worked in terms of monads (be these human or non-human) and did not recognize the constant interplay between actant and environment. In ANT, agency is simultaneously socionatural and sociotechnical—it makes no sense to privilege the actant, be they human or nonhuman, when the interesting work is happening elsewhere, at different scales. Intelligence for the formicidae is always already about a process of externalization—inscribing the world through traces of all kinds which in turn modify the behavior of ants. The unit *Umwelt/*ant evolves collectively. There is a link here with the work of Terrence Deacon (2011) for whom processes of externalization define the ever-higher complexity of life. However, Deacon too puts it all down to the living creature—this is why he cannot see that nonhuman (e.g, computers) can be 'teleodynamic', just as living forms are. By creating the sharp divide, he falls into the same actant error. At the end of the day, it can be maintained that actor-network theory historically had a tendency to put human agency first; it was rare to get an account such as Callon's (1986) where the non-human (the scallops) gets first analytic billing, and even then they are arguably not particularly agential. While actor-network theory came closest to ANT it would have taken some humility for humans to recognize that their species-specific externalizations (of knowledge in books, of carapaces in cities) constituted just one form of persistent intelligence, and not necessarily the best. We refer the reader to the ANT manifesto we recovered, which is appended to this piece.

[19] The difference between the hive and the distributed collective intelligence proposed by Dr. Vy is that each organism retains its specificity while participating in group objectives where necessary, which means the different organisms exist in balance. Not all interactions can be completely non-violent in nature, given that different species survive on each other—at least for now, the goal of DCI is to retain the balance between different forms and kinds of intelligence.

[20] This is the fun argument: that we have to think of human survival in the same way as we think of other species in a complex system. Hence co-evolution becomes the keyword, in this and the next note. We cannot be certain of the impact of the removal of different species from the planet, but we know that different species exist in relations of codependence (we can compare this with the concept of keystone species). Thus, long-term ecological planning privileging the evolution of one species to the detriment of other species is likely to harm both in the end, or to produce unexpected side effects.

[21] Co-evolution—because we did co-evolve from primordial earth. Talk of the technological singularity (Kurzweil 2006, Shanahan 2015) sees us as evolving towards a single planetary being (cf. note 22 below). The figure ground shift in Ant Network Theory is to see that this was always so. At the broadest scale, geodiversity begets biogeography, which begets geoengineering, which creates new forms of geodiversity, and so forth in loops happening at all temporal scales.

[22] Long-term grips direct survival of the species, while short-term grips direct survival of individual beings. The interaction of the two leads to the evolution of intelligence itself. Machines and biological beings need energy in different forms to survive, but survival itself is not the guarantee of intelligence, which also depends on self-reproduction. But to think of machine intelligence evolving to superintelligence strictly in terms of biological evolution necessitates mimicking the whole chain of evolutionary development from the single-celled organism to sentient life. To think of the development of artificial intelligence in human terms is to imagine humans as the limit of intelligence as well, and identifying artificial intelligence as an existential threat to humanity is to imagine humanity as the prime object and necessity of evolution. In contrast, thinking in terms of non-separation of the living and non-living might help us move away from the metaphors of biological intelligence and social evolution and indeed away from the anthropocentrism of imagining artificial intelligence, toward the shared future evolution of intelligence itself.

[23] Drawing in part on geologist James Dwight Dana and Edouard Le Roy both Pierre Teilhard de Chardin and Vladimir I. Vernadsky: "endeavored to explain the appearance of the reflective mind through the evolution of organisms, and to predict its future development by transforming the whole history of the universe into a 'biological history.' Vernadsky, a biogeochemist, aimed to place humankind into a geological history by investigating the relationships of inert and living matter" (Levitt 2000: 163) For de Chardin: "Under the cover of inert matter, a "biological layer" exists and existed from the very beginning. This means that the beginning of "biology" and the beginning of the initial granulated World were simultaneous events" (164).

[24] 6th? Or the last? How do we categorize and classify extinction, including of our own species?

[25] South America is the source of several invasive ants imagined in SF, especially in several primary texts we considered in our early history of SF ants, be it H.G. Wells' (1905) "Empire of the Ants" or Premendar Mitra's (1931) *Pipre Puran*. In rewriting the SF history of ants in our thought experiment, we thought it fit to locate the original ant invasion in South America where these different narratives are connected.

[26] 'Synching' is a core term here. Synchronization as a process has been central to Western history since the Enlightenment: bringing all of humanity onto a single timeline —it was what allows a single (if false) story of history to be written. Gabriel Tarde (through his development of mimesis) ties synchronization to progress —we transmit and copy the best ideas (see Candea 2010). Synchronization is what allows computers to beat the remorseless—but too slow—ticking of the computer clock (Bowker, forthcoming 2019) by allowing parallel rather than serial processing. These three examples are not so far apart from the point of view of world (rather than anthropocentric) history. The first is a story of synching

the metabolism of the globe (Hornborg 1992); the second synching humans with their machines within this metabolism, and the third uses the principle of the division of labor to organize the life process—clearly decentered from humanity—most efficiently. Synchronization is a core feature of civilization and colonization.

[27] Post-speciesist thought is the bedrock of anti-anthropocentrism in the nonhuman turn, which also embraces the coexistence of different lifeforms (Bogost 2012, Grusin 2015). Philosophy of biology refers to the theoretical difficulty if not impossibility of defining species in the first place (see, for example, Zachos 2016).

[28] In a famous short story "Gamanush Jaatir Upakatha" ("The Story of the Gamma-Men") by the satirist Parashuram (Rajshekhar Basu) (1945), humanity destroys itself in nuclear wars, but the radioactivity produces the next intelligent species: the "gamma-men," which are evolved rats, just as movies such as *Them!* or *Phase IV* imagine nuclear radiation as the cause for the evolution of intelligence. However, the evolved rats are no better, eventually developing their own nuclear weapons and annihilating each other, and so on. Thinking of evolution, of any single species, without consideration of co-evolution of other species, as well as the planet itself, is likely to lead to this cycle of futility.

[29] Mandula is also the name of a character in Premendra Mitra's (1931) *Pipre Puran*. He is identified in the narrative as a prominent Black entomologist, who, together with the Bengali narrator first locates the species of superior ants in South America. Amongst Bengali authors of the period, Mitra is unusual in giving prominence to a Black scientist. Such a move towards the "global south"—scientists of Asian and African ethnicity in Latin America, decenters the usual, predominantly North-centric history of SF itself. Decentering is also part of the objective of this paper, both in the scope and the objective of our arguments, although we engage mainly with the decentering of human worlds and of nature/culture binaries.

[30] Hiveminds are among the most common tropes of science fiction, usually considered as a threat to human individuality. The *Science Fiction Encyclopedia* has a list of prominent examples: http://www.sf-encyclopedia.com/entry/hive_minds.

[31] The reference here is to Spofforth, a Make 9 robot in Walter Tevis' (1980) *Mockingbird*. Spofforth isn't a synth, but a full robot, but their goal is also to save humanity from extinction, a condition humanity brought upon itself by the destruction of other species but also excessive reliance on technology.

[32] What would remain as the archive of the human, after humans have become others? This is a question asked in numerous post-apocalyptic works, in some of which humans no longer remain on the planet, while in others they become observers of their own fall from a mythic/glorious past. The loss of learning or humanity's accumulated knowledge is a central idea, for instance in Walter M. Miller Jr.'s (1959) *A Canticle for Leibowitz* or Tevis' *Mockingbird*, and responses to it also form a part of the SF canon, as exemplified by the *Encyclopedia Galactica* project in Asimov's

Foundation series, itself modeled on the encyclopedic projects from the Enlightenment. H. G. Wells' Time Traveler, another knowledge obsessed scientist like Asimov's Hari Seldon, cannot resist his egocentrism when he comes across the ruins of humanity in far-future Earth:

> "The brown and charred rags that hung from the sides of it, I presently recognised as the decaying vestiges of books. They had long since dropped to pieces, and every semblance of print had left them. But here and there were warped boards and cracked metallic clasps that told the tale well enough. Had I been a literary man I might, perhaps, have moralised upon the futility of all ambition. But as it was, the thing that struck me with keenest force was the enormous waste of labour to which this sombre wilderness of rotting paper testified. At the time I will confess that I thought chiefly of the *Philosophical Transactions* and my own seventeen papers upon physical optics" (Wells 1960 [1895]: 105)

A recent, but no less anthropocentric perspective is found in Larissa Sansour's (2015) post-apocalyptic film *In the Future They Ate from the Finest Porcelain*. Here, too, the discoverers of the traces of lost humans are likely to be other humans, recounting anthropology and archaeology's obsessions with lost cultures, many of them wiped out by the process of colonialism, just as many non-human species are being wiped out in the present. Framed differently in recent years, the question has become: what will humans leave behind: an attempt to imagine how humans will be experienced in a time when they no longer exist. What will human traces be, and how long will they last? Who will these traces be for? Will others, future or extraplanetary species, recognize them? One consideration of such traces and their longevity include the handy chart on the companion website for Alan Weisman's (2007) *The World without Us* (see http://worldwithoutus.com/did_you_know.html). Another example is Margaret Atwood's (2009) "Time Capsule Found on the Dead Planet," where humans leave behind a time capsule for visitors from other planets after humans have gone extinct. We argue that our visitors are displaced in time rather than space: archaeologists of hybrid future species.

[33] There is some debate over what this period was labeled. Traces remain of three different words, anthraxocene, antopocene, and anthropocene. Trail-keepers such as Intominne feel certain that this time period was called "antopocene," given that this was the time when ants took over the planet and engaged in numerous geoengineering projects. Other hybrids, such as the Sritees, prefer anthraxocene, because geospheric records show the widespread use of coal in the same period. The third is generally considered a typo. However, those less concerned with the recovery of traces call the obsession with these traces "obscene," which has become the generally accepted name.

[34] Size and scale are seen as markers of separation, between humans, and between humans and other species… One may think of artificial insects here, many of which are used especially for military purposes, such as the ants in Hannu Rajaniemi's (2016) "Tyche and the Ants," or one may think of artificial bees, etc. Artificial insects represent not just the alien-ness of the insect but also the alien-ness of the machine, and thus occupy a special place in the entomophobic uncanny valley. But far more common in SF has been the fear of the oversized insect. This has been a regular feature when imagining the future evolution of ants in movies such as *Them!* Outgrown, oversized insects are a common feature of many insect-based narratives, also known as big bug films, such as *Mothra* (1961) and *The Deadly Mantis* (1957). Two examples from Mitra's

oeuvre, "Shaytaner Dwip" ("The Devil's Island") (1930a) and "Dr. Sarkarer diary" ("The Diary of Dr. Sarkar" (1930b) play with the theme of *Pipre Puran* on a much smaller scale, this time in an island near Burma, known as the "Devil's Island" by natives. Loosely resembling H. G. Wells' (1896) *The Island of Dr. Moreau* and similar adventures in which a scientist conducts experiments on creatures, in this case bugs, and particularly spiders, to increase their size. The experiment was meant for the good of humanity, as the plan was to use these creatures to reduce human labor. *Children of Time* is similar in that the evolved creatures are meant to be a labor force in the future. In both cases, the experiment fails.

[35] In Mitra's future mythology in *Pipre Puran*, crows, which have long been extinct, are reconstructed through partial information records, and their association with other birds leads the future beings to assume that the species must have been great singers. The corruptibility of information is one interpretation of Mitra's use, but the other, perhaps more poetic one, is to reinterpret the "good": to wonder whether the crow really is a good singer and whether theirs will be a song we will miss if they go extinct.

[36] Although the ants had good genetic evidence for the 'Out of South America' hypothesis, this provided some independent evidence. As noted, it has been argued that the Argentine ant made its way to the other continents through some kind of 'bottleneck,' which led to the invention of 'unicoloniality,' meaning that all ants could suddenly recognize each other as friend and communicate freely (Giraud, Pedersen and Keller 2002). The humans had a strange term for The Great Dedifferentiation event amongst the ants. In an apparent reference to their own history, they called it 'genetic cleansing' of stranger markers due to high nest density in the new ant territories, a necessity during their expansion for the different ant species to form a unicolony (another term apparently from their own history). A key finding was that: "workers from the same supercolony treat each other in a similar manner, whether or not they are from the same nest and whatever the distance between nests. This complete lack of discrimination is particularly striking because workers came from populations up to 6,000 km apart, which encompass a wide range of environmental conditions" (6078). The ants, of course, knew that the dedifferentiation was not about the 'cleansing' of genes but about the origin of consciousness.

[37] Another reference to *Children of Time*, but also other texts that concern themselves with terraforming of other worlds (Pak 2016 has numerous SF examples). Note that the original aim in *Children of Time* was superintelligent slaves who would greet us with open arms. We would be seen as their Creator.

[38] The hybrid names bear vague resemblances to some prehistoric words for memory and memory practices such as minne and smṛti.

[39] While the goldilocks zone is relatively rare, the existence of other habitable planets in the galaxy is highly likely. We can compare this to the Drake equation that is widely used in the search for extraterrestrial intelligence.

[40] This is once again a reference to the hybrid in Goonan's (2016) "Who Do You Love?" and other drowned world narratives common in climate fiction.

[41] A reference to Nick Hayes' (2011) *Rime of the Modern Mariner*, a climate fiction graphic novel that reimagines the polluted ocean. In our thought experiment, pollution too is reclaimed as a space of activity: itself giving rise to the possibility of other life-forms, such as bacteria and enzymes that consume plastic, one of the prime pollutants, or other ways of being and imagining, such as recycled trash *haute couture*.

[42] What would be planetary thought? In *Death of a Discipline,* Gayatri Chakravorty Spivak (2003) coins the term "planetarity" to refer to a new kind of relationship to the planet. In this relationship, the planet is something that both houses us and exceeds our control. Planetarity thus invokes the problem of scale in our relationship to the planet: we live on the planet but the planet does not belong to us. This is opposed to the Enlightenment rationale behind globalization, where the globe belongs to us and is subject to our control as rational agents. Planetarity has been evoked in other discussions, including of the Anthropocene and climate change, where such a new relationship is being registered and conceptualized. The term can be productively compared with Walter D. Mignolo's (2000) "critical cosmopolitanism" and Donna Haraway's (2015) "chthulhucene." In our consideration of the term planetary, we are thinking with and beyond planetarity as discussed by Spivak, to imagine thinking on a different scale of thought that connects all existents of our planet, related to what Michel Serres (2011) calls cosmocracy and the new natural contract.

[43] Takeover of what and when? Perhaps the deserts or the forests of North, Central and South America would be a good place to start looking. In H. G. Wells' "Empire of the Ants," Premendra Mitra's *Pipre Puran*, the first "Big Bug" film *Them!* (1954) and numerous ant movies such as *The Naked Jungle* (Dir. Byron Haskin, 1954) or *Phase IV*, the ant threat always emerges from this part of the world. This has to do as much with colonialism as with the perception of their inhospitable nature. However, these narratives are not all similar in how they present inter-species colonial contact. In Wells' early narrative, the ants are a threat to empire itself, something like a science fictional version of Joseph Conrad's (1899) *Heart of Darkness*, whereas in Mitra, the superiority of the ants is something ultimately to be understood, even if they are a threat to all of humanity, and not only to empire. Mitra's narrator even finds a way to communicate with the ants, and live amongst them, and thus serves as one inspiration for Dr. Vy in this narrative. The other inspiration is Dr. James Lesko, from the film *Phase IV*, who is also able to decode the ant signals, and eventually communicate with them. There is a sense of inevitability in all of them—ants will inherit the earth. But their creation as a superior species is also often attributed to the humans, whether through nuclear pollution or chemical pollution.

[44] There is no way in which humans can defeat the ants, or for that matter, any insect, because it is ultimately like fighting the planet itself. The film *The Hellstrom Chronicle* (Dir. Walon Green, 1971) argued that the natural inheritors of the earth were the insects. In H.G. Wells, this future, where the ants take over the planet has the form of prophecy, while in Mitra it is the memory of another time. In Tchaikovky's *Children of Time* it is an unspecified present. The only way forward is acceptance of this fact, and in that acceptance lies the potential for future coevolution. Even

without the mythos of ant takeovers, the pre-emptive anthropogenic attack on insect species that marks this current era is also bound to affect the survival of humans in the future.

[45] Colonization is the first key argument in human-human and human-non-human contact. In the *Star Trek* universe, the Prime Directive (Starfleet General Order 1) prohibits Starfleet personnel from interfering with the "normal" development of alien societies on other planets that they come across during their explorations. This ethical directive is at the heart of many conflicts in the Star Trek universe, especially as those relate to Starfleet interference with so-called underdeveloped societies even to prevent the possible destruction of such societies due to natural calamities. We argue that interference and non-interference with human and non-human worlds on planet Earth can both be equally damaging, especially since interference is already present (as in climate change): we cannot not act.

[46] The restored original scene in *Phase IV* describes the remaking of the human species by the ants, while Olaf Stapledon (1930) imagines 18 future human species in *Last and First Men*. But 22 is also the seed of the undiscovered hybrids.

[47] We return to *Children of Time* here, and to the process of uplifting.

[48] The Galactic Seeding Project is an advanced terrabioforming project, creating new environmental conditions for the evolution of intelligent life, as well as modifying existing life to suit the modified environment. Eventually, it aims to achieve harmony between the environment and its inhabitants.

[49] Abiogenesis is the emergence of life from non-life. Terraforming is the modification of the environment. Our planet itself is constantly being "terraformed" in order to support its processes. Terraforming is what all life does from archaea onwards but we tend to see the lithosphere as relatively constant, not created. Except when we have the hubris to say humans alone can do it, a common human exceptionalism designated by terms such as the Anthropocene.

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