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CyberGaia: Earth as cyborg

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Since the days of the transcendentalists, most environmental philosophers have assumed a dividing line between human-made technology and nature. In the context of our current technological world and the contemporary environmental movement, this way of thinking is perhaps more pervasive than ever. But from a cybernetic perspective, nature and technology together represent an inextricably connected network of signals and feedback, continuously developing as an organic whole. Drawing from cultural histories of the interconnectedness of life and of the cyborg concept, I propose CyberGaia as a metaphor to describe our biosphere in a fashion which acknowledges human technology as an integral part of nature. In this framework, humanity and technology represent an inseparable constituent of a larger interconnected system. Though CyberGaia does not distinguish nature and technology at a fundamental level, it recognizes that the technological world influences nature's development by acting on the network within which it is embedded. By emphasizing the sublime beauty of nature's interconnectedness, CyberGaia also preserves the spiritual-emotional connection to Earth which has heavily contributed to driving the environmental movement. CyberGaia merges physics and inspiration, encouraging us to create sustainable closed-loop technological systems that enable a flourishing biosphere. I argue that seeing the world as an interconnected cybernetic network may help us to better understand the biosphere in its totality while motivating us to take actions which help protect and preserve CyberGaia's diverse menagerie of human and nonhuman life.

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Introduction

The term "cyborg" derives from "cybernetic organism" and the field of cybernetics describes the fundamental mechanisms underlying the functioning of complex systems (Wiener, 1948). Developed by MIT professor Norbert Weiner (Beer, 2002), cybernetics explores universal mathematical patterns that arise in self-regulating systems such as cells, animals, machines, brains, ecosystems, and societies. To describe patterns, it utilizes quantitative tools such as feedback loops, oscillations, signal processing, information theory, stability and chaos, and statistical thermodynamics. Cybernetics represents the theoretical foundation for modern engineering fields like electrical engineering, mechatronics, automation, communications technology, computer science, and synthetic biology (Grinin & Grinin, 2020; Umpleby, 2005). It also has supported advances in fundamental research on ecosystems (Corning, 1995; Gignoux et al., 2017; Nielsen, 2016), climatology (Kuneš, 2012; Lu & Xu, 2017), and neurobiology (Collins, 2019; O'Connor, 2012; Pulvermüller et al., 2014). Cybernetics furthermore relies heavily on network science (Alker, 2011) and thus lends itself to viewing nature as an interconnected system (Patten & Odum, 1981). Beyond its technical relevance, cybernetics has broader symbolic and philosophical significance in that it offers a way of seeing our world as regulated by patterns of flow and feedback (François, 1999). Cybernetics has shown itself to represent a powerful tool across both engineering and humanities disciplines.

Gaia originated with James Lovelock's Gaia Hypothesis (J. E. Lovelock & Margulis, 1974). With the Gaia Hypothesis, Lovelock and Margulis suggested that the biosphere and the physical environment of our planet interact in a bidirectional fashion that over time induces stabilizing conditions benefitting life. In this way, the sum total of life on Earth may act as a self-regulating system that spontaneously moves towards global homeostasis. That is, Lovelock's Gaia describes the Earth system as a self-regulating superorganism. Though Lovelock's original Gaia proposal has received scrutiny from the scientific community due to a lack of selective pressure at the level of the biosphere (Free & Barton, 2007), it has spawned a number of scientifically tenable variants which retain the underlying spirit of the idea that the biological constituents of the Earth system in some ways directionally act together as guided by a vast thermodynamic-evolutionary dance towards dynamical stability (Kirchner, 1989). In addition, Lovelock has countered critiques through computational modeling of toy systems that illustrate the interplay between biology and its physical environment (Watson & Lovelock, 1983). Bruno Latour has further argued that some scientific critiques misinterpret Gaia as a godlike figure when it is actually a method of distributing causal agency across the Earth system in a continuous fashion (Latour, 2016). Of contemporary relevance, Lovelock expanded his Gaia Hypothesis in the book "Novacene: The Coming Age of Hyperintelligence", wherein he discusses how artificial superintelligence (ASI) may play a benevolent role in stewarding the future of the Earth (J. Lovelock, 2019). Much like many contemporary transhumanist thinkers (Bostrom, 2014; Kurzweil, 2005), he argues we will not be able to comprehend the activities of ASI. Despite this, Lovelock remains optimistic that ASI will create a world featuring a form of technological-ecological harmony since ASI will need to preserve its environment in order to survive. Lovelock's Gaia hypothesis and its extensions represent compelling perspectives on the dynamics of the Earth system.

I propose a philosophical framework "CyberGaia" to bridge the divide between scientific and cultural views of the interconnected world, providing the foundation for a transdisciplinary way of thinking about environmental ethics. In the tradition of Lovelock's writings on Gaia (J. Lovelock, 2019; J. E. Lovelock & Margulis, 1974), I argue that we view the sum total of human civilization and nonhuman biological life as a single developing superorganism. I furthermore argue that both humanity and nonhuman life represent intrinsic constituents of nature, that all life is connected through a continuous medium of biophysical and technological intercommunications, and that humans play an important role in how the biosphere develops. Technology falls under the umbrella of biology and all biology is part of an interconnected whole. While technology integrates into ecological processes in both unsustainable and sustainable ways, CyberGaia suspends deontological judgements on technology since human inventions are a part of its totality. Earth exists in concert with human technology in the same way as a human (or perhaps posthuman cyborg) exists in concert with her or his implanted neural prostheses. Alongside all this, CyberGaia also recognizes that humans feel a deep spiritual-emotional connection with the natural world (Nash, 2014) and aims to retain this sentiment in the context of technology representing an integral part of nature. As such, I speculate that CyberGaia may inspire change in a fashion that blends data-driven consequentialist thinking and the positive motivational aspects of naturalist spirituality. In contrast to the approaches of deep ecology (Drengson et al., 2011) and ecofeminism (Gaard, 2015), this hybrid mindset could guide a utilitarian and emotionally aware perspective on humanity's role as a part of a larger biosphere system in facilitating sustainable growth.

Historically, cybernetics and the cyborg have demonstrated extensive sociocultural influence (Downey et al., 1995; Vydas, 1965). They rocketed to fame in feminist literature after publication of Donna Haraway's paper "A Manifesto for Cyborgs" (Haraway, 1987). In this seminal essay, Haraway utilizes the cyborg as a socialist-feminist political metaphor. She suggests the cyborg symbolizes a subversive mythology which overturns existing social hierarchies and power structures by embracing radical transformation. Haraway lays claim to the cyborg identity since it represents both power and otherness, thus providing a route for those who have been othered to claim power in the wake of an accelerating future. Cyberpunk fiction represents another way that the cyborg has infiltrated cultural discourse. William Gibson's novel Neuromancer serves as a foundational text in cyberpunk literature (Gibson, 1984) which explores the criminal underbelly of a world replete with neurotechnology. It explores concepts such as the immersive virtual reality of the matrix, ubiquitous prosthetic and pharmacological augmentations, and artificial intelligence. Gibson's visionary imagination has spawned an enduring cyberpunk cultural legacy (Renegar & Dionisopoulos, 2011), believably putting the spotlight on how biology and technology can blur together while interrogating the implications of this posthuman tomorrow. More recently, Stephan Lorenz Sorgner has written on visions of the cyborg in the literal context of the contemporary transhumanist movement (Sorgner, 2021). It should be noted that cybernetics has unfortunate ties to military applications, showing that it can be used for destructive purposes (Bousquet, 2008; Schwarz, 2023). In particular, lethal autonomous weapons raise disturbing ethical questions (Brenneke, 2020). As such, there exist ongoing efforts towards international bans on the development and use of lethal autonomous weapons (Russell, 2022). Despite the association of cybernetics with military activity, I argue militarism does not represent an intrinsic characteristic of the cybernetics approach. Rather, it supports the idea that cybernetics has great predictive power, and that great power can be misused. I suggest that we should take this as a lesson to focus on responsible implementation of cybernetics in our technologies. These examples only represent a small subset of the vast array of cultural influences arising around cyborgs, yet they illustrate the power of the cyborg as an impactful mythopoetic figure.

I offer CyberGaia to build upon the cultural history of the cyborg in a fashion that opens doors to alternative strategies for thinking about humanity's relationship with the environment. Much as Haraway used the cyborg metaphor to empower the feminist movement, extending the cyborg to the Earth system could provide a guiding metaphor for an approach to ecological ethics that supports and complements bright green environmentalism, technogaianism, and similar environmental philosophies (Newman, 2011). Once CyberGaia provokes us to envision our world as a superorganism within which technology is inextricably interwoven as part of its biology, cybernetics can play a more central role in discussions about how to handle environmental challenges like climate change. Our world is a complex dynamical network from which technological influence cannot be separated. With CyberGaia, technology represents an instrument of nature. This view runs counter to the common assumption that human intervention in nature is intrinsically bad or inevitably doomed to cause more harm than good (Latour et al., 2018). In this line of reasoning, I do not wish to minimize how past human missteps have led to ongoing ecological crises. I instead propose that seeing the Earth as a complex technologically integrated system may aid and inspire decision making for addressing environmental challenges.

Technology is biology

Many prominent thinkers have contemplated the interconnectedness of nature while distinguishing humanity, technology, and industrialism as forces that oppose natural systems. Transcendental philosophers like Henry David Thoreau and Ralph Waldo Emerson embraced ideas of nature's interconnectedness (Schober, 2015). However, these figures also argued that industrial civilization represents a corrupting influence on nature, creating separate concepts of the transcendently sublime wilderness and the desolately unnatural expanse of the built environment (Reynolds & Lynch, 1979; Thoreau, 1854). Influential poet and environmental activist Gary Snyder draws inspiration from *Hua-Yen* Buddhism to propose a form of moral humanism which decenters the human aspects of nature, spirituality, and ethics (Takahashi, 2002). He argues that the material trappings of civilization have moved humanity away from the natural world. While interconnectedness represents a common theme in ecological philosophy, those who promote its importance frequently level heavy critiques against humanity's technological civilization.

I argue that the perceived moral division between purportedly unnatural technological systems and natural biological systems is an arbitrary categorization. I will first state that this argument operates under the assumption of physicalism and that physicalism supports the indivisibility of nature and technology from an ontological standpoint (Ducarme & Couvet, 2020; Poland, 1994). An entirely physical universe, rather than a cosmos divided between natural and supernatural, struggles to separate technology from nature since the very notion of "unnaturalness" does not exist. Though this argument is necessary to support technology as a part of nature, it is not wholly sufficient. Skeptics may contend in favor of separating biology and technology on the basis of differing sets of intrinsic characteristics, so I will counter by providing evidence that technological systems and biological systems share a surprising amount of the qualities most commonly used to divide them. At its core, technology can be thought of as organisms altering their environments through physical reconfiguration of matter to achieve some useful purpose. The organisms in question need not be human; a rich diversity of nonhuman animals utilize their own technologies (Hansell & Ruxton, 2008; Seed & Byrne, 2010). Honeybees, termites, birds, beavers, primates, ants, and many others have their own ways of altering their environments through physical rearrangement of matter. Some might suggest that human technology is different because it does not rely on instinct or relatively simple algorithmic patterns, instead leveraging creativity to adapt to new challenges. But even the strategy of using creative cognition to plan rearrangement of matter in the environment does not solely belong to the human domain. In a particularly striking example, honeybees demonstrate complex reasoning, adaptability, planning, and creativity in comb building when confronted with evolutionarily novel obstacles like translucent barriers (Gallo & Chittka, 2018). To avoid comb construction colliding with an experimentalist's slippery glass wall, bees have shown the ability to plan ahead, closing off the edge of the growing comb with a geometrically creative cylindrical curve rather than having to stop unexpectedly upon reaching the glass obstacle (MacLean et al., 2014). While this kind of architectural innovation represents somewhat a rarity in nonhuman animals, the fact that it occurs at all (and especially from invertebrates) supports the notion that technology and biology are not separable by intrinsic qualities. While human technology sometimes involves more layers of abstraction than that of nonhuman animals, it does not represent a fundamentally different practice.

Why use the cyborg metaphor?

The term CyberGaia draws attention to how human technology acts as an inseparable instrument within nature's cybernetic networks. Technology represents a functional part of cyborg biology and likewise technology represents a functional part of CyberGaia's ecosystems. This does not mean that technology always benefits ecosystems. After all, improperly deployed technologies (both human and nonhuman) have very often contributed towards ecological degradation. Rather, it means that human technology has functional significance as part of the biosphere. Human technologies can benefit or harm the dynamical stability of the global system where they are embedded. It is up to the subnetwork comprising our civilization to elucidate ways of implementing technologies in a fashion that most broadly benefits life on Earth. Describing Earth as a cyborg sequesters the potent symbolism of cybernetics (Haraway, 1987; Sorgner, 2021; Vydas, 1965) and thus presents our global system as constantly changing, self-regulating, replete with loops and oscillations, and possessing potential for dynamical instability or stability. As a conceptual framework, CyberGaia places front and center the idea that technology has power while acknowledging that technology is integrated into a larger whole. Humanity's built environment is like a neuroelectronic second skin upon the Earth, an adaptation that helps achieve some aims while adding new burdens that must be smoothed out as humanity learns improved methodologies over time. CyberGaia emphasizes both the continuity of technology with nature and the practical reasons why technology needs to adapt to the world where it is embedded.

As an analogy between the more well-understood idea of the cyborg as an individual person and the less familiar CyberGaia, consider cyborg artist Neil Harbisson (Pearlman, 2015). Born with achromatopsia, Harbisson worked alongside scientists and clinicians to develop and implant the Eyeborg, a technological extension of his own body. The Eyeborg consists of a camera on a stalk extending from Harbisson's head which translates colors into audible vibration frequencies in his occipital bone using an osseointegrated chip. Harbisson has been able to memorize and incorporate 360 different colors into his daily cognition. His brain has reportedly shown neuroplasticity in response, adapting over time so that interpreting this range of colors through tonal frequencies now comes organically to him. He utilizes his posthuman abilities for making unique performance artwork (e.g. "color concerts"). Harbisson's Eyeborg acts as an instrumental component of his physiology, enabling novel forms of creative fulfillment. Much like the relationship between some human technologies and the nonhuman remainder of the Earth system, the first iteration of Harbisson's Eyeborg did not integrate well with his biology (Pearlman, 2015). Early versions of the Eyeborg featured a bulky computer and transmitted visual information through sound-producing headphones rather than vibrations in bone. Harbisson experienced painful headaches as a result. Despite these challenges, Harbisson upgraded his technology to its present form, attaining a more seamless experience without the harmful side effects.

Harbisson's story parallels ongoing events at the global level; ecological problems have arisen from early maladaptive technological systems, yet emerging "upgrades" have potential to integrate human technologies more sustainably into the Earth system. Just as Harbisson's own technological upgrades more seamlessly integrated the Eyeborg system into his body, methods such as sustainable energy (Hussain et al., 2017), carbon capture (Olabi et al., 2022), synthetic biology (Tan et al., 2022), vertical farms (Al-Kodmany, 2018; Despommier, 2013; O'Sullivan et al., 2020), cultured meat (Hubalek et al., 2022), green architecture (Chen et al., 2010; Ragheb et al., 2016), and green urban planning (Heymans et al., 2019; Puchol-Salort et al., 2021) could better integrate technological cycles into the biosphere. In this context, I envision new strategies closing loops over global cybernetic circuits. Self-regulating autonomous systems could facilitate worldwide homeostasis by guiding cyclic resource transformations and preventing accumulation of waste products like greenhouse gases. These solutions are by no means inevitable, they will necessitate a coordinated worldwide effort. Harbisson's pursuit of physiologically sustainable upgrades is comparable to the broader CyberGaian pursuit of ecologically sustainable technological upgrades towards future environmental homeostasis.

I furthermore leverage the cyborg metaphor as a way of juxtaposing against established narratives of environmental philosophy, which emphasize that technology, industrialization, and human progress are invariably destructive forces (Drengson et al., 2011; Gaard, 2015; Latour et al., 2018). As a key example, Isabelle Stengers has contributed extensively towards entrenching this narrative into environmental philosophy. In the context of Gaia, Stengers has argued that human civilization specifically does not represent a force of nature (as the term Anthropocene may suggest), but rather a disturbance in the natural order of the Earth (Latour et al., 2018). She has suggested that the modern project of progress is tied to widespread devastation and that scientists, particularly scientists who create advanced technologies, are complicit in crimes against nature. Stengers favors slowing down science, decreasing its focus on technological innovation, and preventing science from interacting with industry (Stengers & Muecke, 2018). Interestingly, she also has argued that neo-pagan witchcraft should be employed to fight against the apparent pervasiveness of capitalism (Harvie & Milburn, 2018). I utilize CyberGaia to resist these narratives by positioning Gaia as a cyborg entity, a dramatic contrast which provokes reexamination of the assumptions made by Stengers and her allies (Lemmens, 2022; Stengers & Muecke, 2018). I argue that normative judgements of technology, industrialization, and progress as morally corrupt forces are misplaced. While at first glance, a cyborg may appear frightening or alien, a closer examination reveals her as a manifestation of nature's sublime beauty (I will explore this with more depth in the next section). As I discussed earlier, technology is a part of nature, so the machine components of the cyborg are simply biological adaptations. While these adaptations were selected for in the landscape of the memetic replication of human knowledge rather than through the replication of nucleic acids, they possess no less intrinsic moral or aesthetic value. As such, the desirability of outcomes associated with specific technologies is a separate question from the inherent character of technology as a whole and thus such outcomes should be evaluated on a case-by-case basis. We should not ask whether technological progress is a force of good or a force of evil, we should ask how to best apply technological progress towards sustainable goals of human and nonhuman animal wellbeing. By combining the provocative cyborg metaphor with the Gaia concept, CyberGaia urges us to reconsider the idea that technological progress works in opposition to nature.

The silicon wilderness

The idea of a spiritually meaningful wilderness has repeatedly appeared as the backbone of ecological philosophy and has helped drive conservation efforts (Nagle, 2005; Nash, 2014). Transcendentalist philosopher Henry David Thoreau's contemplative account of his experiences living beside Walden Pond from 1845–1847 contains a wealth of ascetic spirituality channeled through his deep affinity to wilderness (Saunders, 2014; Thoreau, 1854). Renowned American naturalist John Muir wrote of his experiences in the Alaska during the later 1800s, putting forth a poetic and deeply heartfelt account to describe the presence of God in the wilderness (Muir, 1915; Nagle, 2005). As such, early naturalists who have felt a spiritual connection to nature have proven instrumental in shaping the contemporary environmentalist movement. To this day, spiritual emotions and environmental conservation remain closely intertwined (Nocek, 2018; Omoyajowo et al., 2023). To better communicate the importance of naturalism across different groups of people, I propose that the CyberGaia framework should aim to preserve the human emotional connection to nature.

I argue CyberGaia is compatible with a spiritual-emotional conception of the wilderness that encompasses both human and nonhuman parts of our world because of its profound interconnectedness. When examined from a cybernetic perspective, the human part of nature or the "silicon wilderness" possesses its own sublime beauty, a reflection of the larger network wherein it is embedded. Much like the vast metabolism of the nonhuman biosphere, CyberGaia is replete with living flows, signals, and information exchange. CyberGaia adds to the nonhuman web of life via industrial, economic, linguistic, cultural, and techno-metabolic layers which nonetheless remain intimately woven into the underlying mesh of biology. Technology itself is a spectacularly diverse ecosystem. Sextillions of transistors across the world regulate electricity's frantic flow, speaking to us as their energies transform into light and sound. Computational devices listen to our desires by taking in tactile strokes and presses or by recording the sonic vibrations of our voices. All this is another biophysical manifestation of the primordial loop of input, processing, output, and adjustment-feedback via the next input which undergirds all life. Data centers and supercomputers hum with an internal pulsating complexity, eerily reminiscent of the buzzing whispers of molecular computations inside our cells and tissues. Trillions of human conversations leap up into orbital satellites and back down again. There is naturalist spirituality in this global cybernetic buzz. I propose that seeing humanity as an integral part of the wilderness provides an appreciation of the true interconnectedness of life on Earth in all its glorious complexity.

Perhaps Thoreau and Muir would initially express horror at the freneticism of today's globalized silicon world, yet like the woodlands or the glittering ocean or the mangroves or the

Sonoran Desert, humanity's technological civilization is a type of wilderness. Though the silicon wilderness today competes with other ecosystems in an arguably dysfunctional fashion, nature has always experienced oscillations around its fixed points of homeostatic equilibrium. Consider how life adapted to the Great Oxidation Event associated with the emergence of the first photosynthetic microorganisms (Algeo & Shen, 2024; Payne et al., 2011). Technology is nature and nature is self-correcting.

For our own sake and the sake of all life, I suggest humans ought to establish improved lines of communication between the silicon wilderness and the nonhuman biological wilderness. After all, we do not want the outcome of the Anthropocene to resemble that of the aforementioned prehistoric Great Oxidation Event, where the development of photosynthesis triggered the largest ever set of mass extinctions (Algeo & Shen, 2024). Towards this aim, continuous monitoring of environmental conditions through biosensors, minimally invasive robots, and biometric devices could generate a global map of CyberGaia's health. Supercomputers equipped with energy efficient neuromorphic hardware may process these data, convert them into vast prediction matrices, and produce actionable instructions which guide robots and humans to cultivate global homeostasis. I envision that these systems may respond to imbalances in real time to maintain harmonious conditions, facilitating cycles of nutrient and energy transformation with minimal waste. Green nanomaterials in buildings could rapidly clean pollution from the air while swarms of genetically engineered bacteria could keep the soil and ocean pristine. We might even reverse some of the existing damage to biodiversity by utilizing genetic de-extinction technologies, bringing back ecologically critical organisms such as the Thylacine (Sherkow & Greely, 2013). If their risks can be mitigated, oceanic iron fertilization (Aumont & Bopp, 2006) or solar geoengineering (Irvine et al., 2016) tools might allow reversal of global warming. Perhaps ASI will oversee these efforts as Lovelock suggests in Novacene (J. Lovelock, 2019). All this and more will be controlled by cybernetics. Input, transformation, output, and feedback. Branching, regulating, adjusting. Just as the broader wilderness concept has always driven conservation, cultivating a spiritual-emotional-cybernetic connection to the silicon wilderness of CyberGaia could aid environmentalist thinking towards sustainability goals.

CyberGaia and sociopolitical issues

CyberGaia positions humans as an integral subcomponent of the Earth system, so our sociopolitical challenges are interlinked with the Earth's health. Ongoing sociopolitical constraints represent a central difficulty facing the realization of sustainable cybernetic intercommunication between human and nonhuman components of the Earth system. Lenton and Latour have argued that the scientific community has the power to create a sustainable global system through closed-loop environmental monitoring and response methods, but suggest that profit-driven economics suppresses this goal (Lenton & Latour, 2018). I would concur that profit-driven agents (e.g. corporations) cannot on their own show sustainable behavior. With the integrated CyberGaia perspective, I suggest that corporations need some form of regulatory negative feedback to oppose their unsustainable activities. This negative feedback may arise from mounting political pressure to impose regulations on destructive behavior as well as from competitors that leverage the changing social landscape to expand green markets. For example, social recognition of climate change has stimulated proliferation of synthetic biology companies that utilize microorganisms to sustainably manufacture dyes, cosmetics, fabrics, pharmaceuticals, biofuels, and foods (Collins et al., 2023; Voigt, 2020). For similar reasons, renewable energy usage has consistently increased over time and projections indicate that it will continue to grow (Hosseini, 2020; Xu et al., 2019). However, there still remains a long way to go before purely political feedback mechanisms catch up with the process of climate change. In the meantime, I argue that we should not shy away from also leveraging preexisting political structures to incentivize green technological interventions.

Less developed nations have and will suffer more from the effects of climate change than wealthy nations (Mertz et al., 2009), so an awareness of the international effects of environmental challenges is vital from a deontological justice perspective (Ikeme, 2003). Since CyberGaia emphasizes the interconnectedness of all life, it can offer consequentialist reasons for wealthy countries to make certain types of sacrifices towards enhancing global well-being while not expecting the same of less wealthy countries. As resource-rich local subsystems embedded within an evolving global system, developed nations organically are disposed to take on greater responsibilities in the context of environmental challenges. Less developed nations, nonhuman organisms, and habitats do not possess the tools to directly address climate change at this time. But supporting, guiding, and communicating with less developed nations in the face of climate-related catastrophes could have longer term benefits for the system as a whole. By nurturing the potential of developing countries, new environmentally conscious sociocultural centers may emerge over the coming decades. Consider a speculative scenario where 20 years from now, the nations of Africa have grown into a global scientific and economic superpower. Imagine this future Africa has developed through a combination of its own cultural agency and the contributions of other nations to respectfully nurturing its growth. An Africa that receives educational opportunities and enabling forms of aid (rather than aid which fosters dependency) (Loxley & Sackey, 2008; Reiche et al., 2023) will be well-positioned to grow into a superpower that works cooperatively towards sustainable protection of the environment. This illustrates how CyberGaia's interconnectedness operates across long timespans. CyberGaia therefore suggests that deontologically ethical sociopolitical actions can offer utilitarian benefits down the road.

Conclusion

CyberGaia offers an alternative way of looking at the global system which emphasizes interconnectedness, proposes that humanity's technological civilization falls under the umbrella of biology, and maintains a spiritual-emotional connection to nature. I argue that polarizing perspectives where humans are thought of as exploiting or working in opposition to nature tend to encourage fear-driven thinking about the environment. By contrast, CyberGaia represents a way to see nature for what it is, an interconnected cybernetic biological-technological system which retains intrinsic sublime beauty as described by naturalists like Muir and Thoreau. Sophisticated webs of nutrients, electricity, radio waves, sound waves, and chemical signals form and unform and transform across the globe, a coordinated mass of continuously evolving machines. Viewing Earth as a cyborg and seeing nature from a cybernetic perspective may encourage both data-informed and emotionally intelligent decisions about how to best manage environmental issues. We, our technologies, and our institutions are instruments of CyberGaia's physiological feedback loops.

As we witness the dawn of our own future, we must place ourselves in the context of the system in which we are embedded. Life is precious. Technology is part of life. Humans are part of life. Nonhuman animals too. Quintillions upon quintillions of biomolecular computations occur every second to drive the great biological sonata. *Mycoplasma* bacteria. Communities of leafcutter ants. Underground fungal networks. Beloved beagles. Seasonal influenza viruses. Parasitic roundworms. Families of Canadian elk. Vast blooms of cyanobacteria. Humanity. Life works because of complexity that arises from simplicity that in turn arises from the inscrutable quantum mechanical rules buzzing beneath the molecular scale. All creatures from termites to beavers to humans rearrange atoms in various ways. As humans progressed from the paleolithic era to metalwork to industrialization and then to the space age, information revolution, and era of artificial intelligence, we have learned to converse with the atoms around us in an ever more complex fashion. We are actors in an operatic performance, we are subroutines of evolution, we are interwoven matryoshka patterns, an epic chemistry. In the humming of data centers and the calls of whales and the songs of cicadas and the quiet conversations of lovers before sleep, CyberGaia represents us all. To create the best possible future, we ought to fight for the health of our world without fear of the cyborg that is woven not just into human nature, but into the web of life itself.

Data availability

Data sharing is not applicable to this research as no data were generated or analyzed.

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