

interactions

EXPERIENCES | PEOPLE | TECHNOLOGY

GAIAN IxD

Cover Story by Brenda Laurel



GAIAN IxD

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I begin here.

We need to find better ways to look at the Earth and understand our relationships with it. We need to change our notions of human agency within this larger context. I think these changes can be manifested through interaction design—its intents, objects, processes, and methods. This article is a first attempt to describe the opportunity space—what I call *Gaian IxD*—and some design principles inherent in it.

Gaian IxD frames interaction design in global terms. It builds on the growing interconnectedness of science, technology, philosophy, and politics. It responds to changes on a global scale that urgently demand our attention. We can trace its evolution in patterns of invention and emergence over centuries of human existence, through processes that are often reminiscent of biological evolution. Its context is a specific brew of ideas and technologies that have given rise to a particular point of view. We can already see it at work in some domains.

Why bring a *Gaian* perspective to interaction design? *Gaian IxD* may enhance *Gaian* awareness—awareness of our belongingness to the complex dynamic system we call Earth. How can we resonate more deeply within nature? How might we reawaken in people a sense of wonder about

the Earth? How can we become *Gaian* Gardeners, understanding and modulating our actions within meta-human dynamic systems? Timothy Morton uses the term *hyperobjects* to refer to phenomena that “stretch our ideas of time and space” beyond human scale [1]. Can *Gaian IxD* help us to grasp and respond effectively to a hyper-object like climate change?

Vectors of change shoot through the history of HCI and interaction design, from the invention and evolution of technologies to myriad cultural and social transformations that have shaped and been shaped by interactive media. Recently I reconsidered some of the changes in the field during the 35 years I’ve been actively involved in it, as well as some other important events in human-technology interaction. I arrived at the notion of *Gaian IxD* through that journey. Here are some precursors to the idea I found along the way:

Immersion and Emergence: Mush Morton’s Periscope. I began my analysis with an example from before my birth—the periscope, as it was used by celebrated Captain Dudley “Mush” Morton, commander of the USS *Wahoo* during World War II. I was struck by Morton’s story, because he did something unusual with the periscope interface: He handed it over to his executive officer, Richard O’Kane. Morton discovered that

using the periscope, especially in times of battle, was too immersive for him to be effective in his command duties, so he had O’Kane look through the periscope and report what he was seeing [2].

The “designed interaction” with the periscope produced emergent emotions and actions that were unplanned and unforeseen. Although they affected Morton’s ability to concentrate on his job, some of these emergent phenomena were later put to good use in applications such as teleoperations and remote presence. The ability to move the periscope around—to take consequential physical action—was a major contributor to the sense of immersion. The principle of action later became key to designing immersive interactions in such interactive schema as virtual reality [3].

Earth from Space. Another milestone in human-technology interaction—one for which I was quite alive at the ripe age of 18—was the Apollo 8 moon mission. Launched on midwinter solstice in 1968, the mission marked the first time that human beings left Earth’s orbit, entered the orbit of the moon, and returned safely home. The most profoundly consequential cultural symbol produced by that mission was the first image ever taken directly by humans of the entire Earth. One might quibble that this image was not “interactive” as we

now understand the word, but in 1968 the most interactive thing most of us could do with technology was change the TV channel. The image, probably shot by Lunar Module Pilot William Anders, was an artifact of an enormous and enormously complex interactive experience involving thousands of people and technologies.

The elements of nature in the image were colossal and were both experienced and represented in unprecedented ways. Likewise, the image had enormous cultural impact. It was featured on the cover of *LIFE* magazine, assuring its near-global ubiquity. Stewart Brand founded the *Whole Earth Catalog* the same year; its first issue featured a cover photograph from the same source, signifying an emerging worldview. In his 1972 book, *Myths to Live By*, Joseph Campbell writes that upon seeing our first images of Earth from space, we suddenly understood that rather than coming into this world, we come out of it [4]. A moment in the unfolding of a “designed interaction” can have monumental—even mythic—consequences.

The Arab Spring. The history of interaction design is non-linear. As the field evolved between the 1970s and today, interaction morphed from one-to-computer to, mediated by technology, one-to-one, one-to-many, many-to-many,

Photograph by Hilary Nuttgen



► Water Striders

and into a realm of complexity—as illustrated by the huge role played by interactive devices and systems in the “Arab Spring”—that involves one-to-many-to-many ones-to-broadcast media, and so on. As in Gaia (“Earth Mother” in Greek mythology) herself, there are systems within systems at work, both technological and human—some of which are structurally constrained, some of which exhibit chaotic dynamics, and some of which produce *emergence*. In the Egyptian revolution, profound political changes

emerged from the particular stew of communication technologies and media transmitting, shaping, and amplifying the energies of individuals and groups [5]. The processes involved were wholly unlike the historical forms of coup d’état, in which strategies and tactics aimed at specific outcomes were based upon grand strategic goals.

The Arab Spring exhibits complex, emergent interaction at the level of cultural and political entities. A next permutation of IxD might step up to a Gaian

scale. Meaningful interactions in Gaian directions already exist, but the Gaian view has not yet become a meme—part of popular consciousness. To *intend* Gaian IxD means beginning from what may be a radically different notion of life. It means to “wake up and find out/that you are the eyes of the world” [6].

A Gaian Perspective

What are the defining characteristics of Gaian interaction design? The first is surely the assump-

tion of a Gaian perspective. The Gaia theory, or Gaia hypothesis, comprehends Earth and all its constituents as a single, complex, self-regulating system—an entity with complex interrelated systems at all levels of scale—that maintains conditions for life. In the 1960s, James Lovelock was a visiting scientist at Jet Propulsion Laboratories in Pasadena, California. He began work on what we now know as the Gaia theory to describe those characteristics of a planet as seen from space that might identify it as a system supporting life. In his 1979 book, *Gaia: A New Look at Life on Earth*, Lovelock unfolds the Gaia hypothesis, arrived at through his collaborations with microbiologist Lynn Margulis and others [7]. Gaia, Lovelock says, is “a complex entity involving the Earth’s biosphere, atmosphere, oceans, and soil; the totality constituting a feedback or cybernetic system which seeks an optimal physical and chemical environment for life on this planet” [8]. In her book *Symbiotic Planet*, Margulis explains that Gaia is “an emergent property of interactions among organisms” [9]. In the years since its initial publication, the Gaia hypothesis has been tested through such a variety of scientific means that it is now widely accepted among the scientific community.

Lovelock remarks, “...I find that country people still living close to the Earth often seem puzzled that anyone should need to make a formal proposition of anything as obvious as the Gaia hypothesis. For them it is true and always has been” [8]. Lovelock’s observation does not deny that humans are entities unto themselves, but it does suggest that most humans relate to Gaia in much the same way that the trillions of microorganisms in our bodies relate to us. A tree also has relatedness to Gaia but offers different services, if you will, to the larger whole.

Humans offer particular intelligences: the ability to evince detailed and complex self-awareness, the power to extend our agency beyond our bodies through technology, and both consciousness of and curiosity about the larger contexts in which we live—cultures, civilizations, Earth, and the cosmos. These are unique contributions. They enable us to have such a large influence

over the Gaian whole as to cause highly consequential effects, including palpable harm. The prime characteristic of a Gaian perspective consists of awareness of our relatedness to the whole Gaian entity. We are not alone.

Nested entities. A Gaian perspective cultivates a deep understanding of nested entities and the complex relations among them. Rob Tow proposes a definition of what constitutes an entity in this way: An entity demonstrates what Tow calls a “perception-representation-action” (PRA) loop in its behavior. It can perceive its environment, it can construct an internal representation of its perception, and it performs actions based upon that representation [10].

Consider a water strider as an entity. Water striders (pictured at left) live in groups in slow-flowing streams and other bodies of fresh water, dining mostly on fallen insects and spiders. Water striders sense their distance from their fellow striders through the characteristic vibrations caused by their movements, distinguishing those particular sensations from other sources of vibration in the environment: perception. The perception of these vibrations is transduced into signals that activate the insect’s muscles—a representation—causing it to take action when necessary to maintain optimal dispersal over the surface of the water where the water striders are situated. Consciousness of what one perceives or conscious decision-making to take action are not necessary elements of what Tow calls representation; this part of the loop requires only that perception be transformed into triggers for action. (Consciousness and intention are not necessary in the Gaia theory, either.) A water strider is

Photograph by Martin C. Ewins



► An early Gaian IxD inspiration: The first image of earth taken by a human.

an entity, and a particular group of water striders inhabiting a specific territory can be seen as an entity as well. Conversely, a plastic bottle floating down the same stream does not qualify as an entity, even though it can be made to perform actions, because it has no PRA loop.

In humans, of course, PRA loops are infinitely more complex, elaborate, and interrelated. In conscious or intentional behaviors, the representation may involve processes of logic, analogy, and so on. As in the classic Eames film *Powers of Ten* [11], we may move up the scale to aggregates of humans. The PRA loop helps to elucidate how groups and organizations can constitute entities: human ecosystems.

Ecosystems as entities. The science of ecology is a field within the larger purview of biology. Ecologists study the relations among heterogeneous entities (and nonentities) that constitute systems that are distinct and reliant on a particular set of (dynamic) relations among their elements. The overall pattern

of these relations is what distinguishes a particular ecosystem. While an ecosystem (such as a swamp) may survive without some of its usual constituents (frogs), there is a tipping point at which an ecosystem ceases to exist as an entity because a critical level of loss or change is reached, destroying the pattern of relations that make up the dynamic whole.

From a Gaian perspective, ecosystems are entities with nested and interrelated PRA loops. Interestingly, this view includes nonentities like minerals, not because they have their own PRA loops, but because they may be necessary elements in the collective of relations that form the ecosystem itself. Lovelock had the same view in terms of the non-living elements of Gaia. Like Russian dolls, ecosystems themselves are entities nested within one another, all the way up to the scale of Gaia itself, and probably beyond.

Reframing Gaian Relations

Ecology suggests that biologically living creatures cannot easily be separated from non-living materials at the level of an ecosystem. Similarly, technology cannot easily be separated from the living beings that extrude it. At least since that first proto-hominid picked up a rock and bashed somebody with it, all bets have been off for strictly biological models of evolution. Our tool-making ability—an extrusion of our particular intelligence—has made humans as a species able to act with increasing magnitude through extensions of human perception and agency.

Technology is not the other.

Discourse and literature typically default to a colloquial positioning of technology as an “other.” Yet, remembering that photo of Earth

from space, one can see there is nothing on this shining blue ball that is non-Gaian; even the asteroids that have embedded deposits of nickel deep into Earth’s crust are now part of the grand ecosystem. Technology has been invented by entities as diverse as crows, raccoons, and marine mammals. Like Vernadsky’s and de Chardin’s “noosphere” [12], our technologies are extrusions of ourselves, and thus also of Gaia. Joseph Campbell described our first view of the Earth from space as “the first time the Earth was able to look back on itself through the eyes it had grown in human beings” [13].

Significant new affordances we have created for ourselves to see the world have inevitably caused tectonic shifts in human thought and agency. The twin affordances of the telescope and microscope are obvious examples. These technologies not only reframed our understanding of the world and ourselves but also opened the way for the emergence of entirely new landscapes of capability, from epidemiology to aerospace. What new capabilities, intentions, and actions will emerge from technological extrusions like computing and sensor networks? In relative historical terms, we have had only the merest glimpse.

Nature is not the other. In his book *Ecology Without Nature*, Timothy Morton sees the central flaw in the concept of nature as the distinction it suggests between “us” and “it.” In his introduction, Morton says that “...in all its confusing, ideological intensity, nature actually impedes a proper relationship with the Earth and its life forms, which would, of course, include ethics and science” [14]. In adopting Morton’s way of thinking about ecology without “nature” as a differentiator, he says,

"we are now compelled to achieve ways of sorting things out without the safety net of distance, ways that are linked to ways of sorting things out ethically and politically" [15]. If Gaia consists not only in the nested entities of life on Earth but also in the relations among them, then ethics and politics are examples of such relations.

The "othering" of nature gives rise to seemingly innocuous concepts like husbandry, stewardship, conservation, and preservation. But each of these concepts implies a self-and-other relationship with the natural world, and each can give rise to its own flavor of hell—for example, embedded power relationships that might be described as patriarchal, which are weaker forms of the sort of manipulations, conscious or unconscious, that have brought us to the imminent threat of catastrophic climate change. The darker side of the conservation and preservation movements look to the return of a status quo ante as an idyllic state, denying the dynamic nature of Gaian systems and the constant of change, and running the risk of creating systems that are more brittle than adaptive.

My goal is not to disrespect nature writing or ecological thought, nor to critique environmental thinking and writing, as Morton does. It is to remind us that the words and concepts we use to talk about the natural world can unintentionally sever us from it if we're not careful.

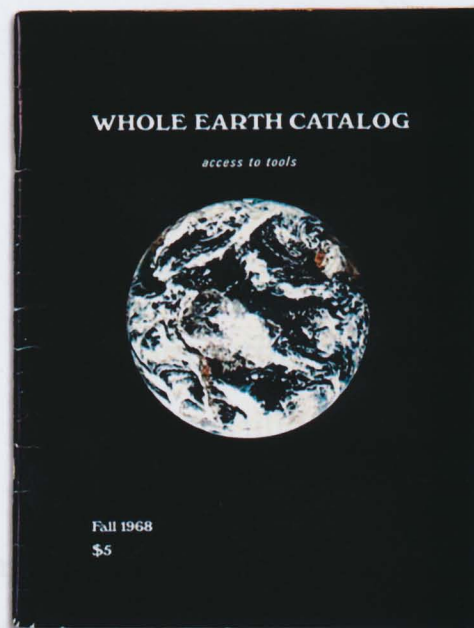
A particular quotation from Barry Lopez has come up for me in many of the projects I've worked on over the years. In his essay "Landscape and Narrative," Lopez observes that most indigenous peoples perceive a sacred order in the land, in which both material and philosophical aspects of their cultures derive

from "observations and meditations on the exterior landscape." He continues: "Each individual, further, undertakes to order his interior landscape according to the exterior landscape. To succeed in this means to achieve a balanced state of mental health." He advocates for "continuous attentiveness to both the obvious (scientific) and ineffable (artistic) orders of the local landscape" [16]. This spirit of attentiveness animates Gaian IxD.

Heuristics for Gaian Design

An important stage in design research is when one translates findings into design heuristics. I speak of "heuristics" rather than hard-and-fast principles because, especially in complex opportunity spaces, flexibility is essential. Heuristics are rules of thumb that are meant to help us translate what we observe into what and how we design.

Consider Gaian scale. Scale exists in many dimensions, from size to time to depth. "Gaian scale" implies awareness of the largest-order entity even when we are considering the smallest. The emergence of Gaia began with (or before, in some analyses) the emergence of what we typically call life on Earth, around 3.5 billion years ago. Of course, humans have been around for a minuscule percentage of that time, about 100,000 years. We begin to see evidence of what is likely human-caused climate change about 10,000 years ago, with the advent of rice cultivation [17]. Scientists generally agree that the rate of climate change is increasing, according to many indicators. Projections vary, but by extrapolating from existing dates, it is thought that, for example, the Arctic may be ice-free by 2040. In terms of a Gaian time scale, the process of climate



change—invisible to most of us in our daily lives—appears dramatically compressed.

In a dimension we may call depth, we may experience increasingly compelling effects. In some virtual reality (VR) and augmented reality (AR) applications, participants report a sense of dissolution of the boundaries of their physical bodies at certain levels of sensory immersion. In correspondence with Barry Lopez, I mentioned one such report from a user of an AR application called the Electronic Field Guide (described below). Lopez replied: "I want to say I have been tracking this for a long time, but, despite my conviction that the experience is common among many traditional people still today, I am not able to fathom what is going on or what the threshold of the experience is all about. To court it, I try for a state of extreme vulnerability to a place, an openness to its numinous presence" [18]. In a recent symposium, Lopez referred to what I would call Gaian depth. When

► The first issue of the *Whole Earth Catalog* depicting the emerging worldview.

In science, holes
in hypotheses lead to
new questions, new
hypotheses, new
science—and when we
are fortunate—new
understanding and
new capabilities.

asked whether he considers himself to be using magical realism in his writing, he replied, "I wouldn't call it that; I would call it 'going deep'" [19].

Engage senses and emotions in Gaian pursuits. Computer scientist Sean White recently worked on the Electronic Field Guide (EFG), a large-scale collaboration between Columbia, the Smithsonian, and the University of Maryland. The vision for the project was to explore new forms of field guides that enhance cognition and memory. The project's explicit purpose was to serve botanists and other scientists in identifying plants and observing or visualizing some of the relationships at work in their ecosystems. As White explains, "If a botanist is studying a caterpillar, they may not be able to identify the species of plants that it eats. The system will help them create an ecological web of relationships and perhaps even help build a semantic web for further eco-informatic study" [20].

The EFG experimented with multiple cameras and sensors as inputs and with hardened tablets, augmented-reality displays, and mobile phones as UI devices. White observed an interesting difference

between scientists using tablets and those using head-mounted AR displays. Those using tablets typically conceived of the process as data coming from a sensor near the plant, transmitted to the computer, which represents it on the tablet display. Scientists using AR displays were more likely to construct the interaction as the data coming *from the plant*. In this case, the AR display (and its particular sensory qualities) effectively collapsed the cognitive mediating distance between the plant and the scientist. This effect was particular evidence that White was meeting his goal "to support being in the world and *part of the world*." Indeed, some scientists expressed a sense of being physically part of the environment, no longer bounded by their physical bodies.

I have made arguments for decades about the narrative content of video games. Sadly, it continues to trend toward representations of the culture of war as a recreational activity. Rather than extending that old argument, I want to point to some examples of what I consider Gaian IxD, some of which are in the realm of games. Gaian IxD is necessary right now as we try to get our arms around the hyperobject of global climate change.

I ran across an online game created by researchers from MIT with a grant from NSF called *Vanished*. The goal of the game was to teach and enliven the practice of science among middle-school students; it required scientific observations and collaboration among students in different places. As the MIT alumni site describes it, the game "will unfold over the course of eight weeks. During that time, kids will receive clues about a fictitious environmental disaster and will work to discover the cause" [21]. Here we see

the substitution of a fictitious environmental disaster for the hyperobject of climate change. Given the scale and scope of climate change, it is no wonder that a fiction was chosen to stand in for it. How might such a game represent climate change, after all?

In the *Poetics*, Aristotle identifies one of the central distinguishing characteristics of drama as its compression of time in the selection and arrangement of incidents. That's how the generation-length action of the *Oresteia*, for example, was presented as three plays, each of which could be taken in within the attention span of an audience. Dramatic compression could also be used to visualize climate change in a way that could be grasped by an audience. The folks on the MIT team did the next best thing: They generated a future scenario in which aliens studying Earth couldn't understand what had happened to it because all the data from previous civilizations had been lost. The mystery was to discover what had caused that erasure. By scoping into the future and exercising dramatic compression, the MIT team was able to indirectly represent the hyperobject. I wonder, however, if and how players made the leap to understand what was behind that representation, and whether a sense of urgency and scientific motivation was engendered around the topic of global climate change. Despite these questions, I see *Vanished* as an example of appropriate purpose and content for Gaian IxD.

Make the invisible visible.

Information graphics—especially dynamic ones—are an excellent aid in representing the climate change hyperobject. Many excellent sources exist; for example, the website realclimate.org includes a variety

of graphs and visual representations, including a stunning view of 2,000 years of sea-level change [22]. Realclimate.org describes itself as “a commentary site on climate science by working climate scientists for the interested public and journalists.” The development of more interactive components for “the interested public” would likely engage a greater audience. Here is an opportunity for more Gaian IxD.

The Miraikan “Tsunagari” Project in Tokyo combines excellent representation with interactive components. Geo-Cosmos, a high-resolution globe created of organic LCDs, shows Earth overlaid with layers of data, from weather patterns to the migrations of bluefin tuna. I experienced a sense of wonder just reading about it. One of the branches of the project, Geo-Palette, is an online service that enables participants to populate their own world maps with data chosen from hundreds of options, to create and share their own juxtapositions and discover new correspondences [23].

Abundant scientific findings support Lovelock’s assertion of the value of biodiversity in maintaining the balance of complex interacting systems necessary for the continuing functioning of the Gaian system, including support for life. In 2007, eminent biologist E. O. Wilson won the TED Prize [24], enabling him to express a wish that a monetary award and the engagement of the TED community network would help him realize. Wilson’s wish was to “work together to help create the key tool that we need to inspire preservation of Earth’s biodiversity: the Encyclopedia of Life” [25]. Early on, Wilson garnered over \$50 million in funding, and the site launched on February 26, 2008 [26]. Overwhelmed by more than 11 million page views,

it crashed in less than six hours and came back online later in the day [27]. The contributors to this enormous collaborative effort are organizations and individuals vetted throughout the world.

Distributed computing projects utilize the CPUs of participants’ computers while they are not in use to generate and explore models of complex systems. Current projects include problems as diverse as the search for extraterrestrial intelligence (SETI), protein folding, and the search for methods of hydrogen production. Climateprediction.net (CPDN) is devoted to improving climate models and increasing understanding of how they respond to small changes. The site provides affordances for participants, including discussion groups, publications, and statistics about participants’ contributions.

The first step is to download the BOINC (Berkeley Open Infrastructure for Network Computing) client software. Unfortunately, the BOINC UI is geeky and uninviting, and the feedback for participation in the CPDN project lacks motivational qualities. Statistics, competition with others, and good feelings may work for some, but providing contributors with a more immediate, sensory, and even interactive representation of the project would be worth the effort to broaden participation. This is a Gaian IxD opportunity.

Participatory sensing is another way for individuals to participate in large-scale efforts that involve gathering huge amounts of data to look at complex problem spaces. Deborah Estrin, director of the Center for Embedded Networked Sensing at UCLA, describes the opportunity space:

Participatory sensing systems leveraging mobile phones offer unprecedented

observational capacity at the scale of the individual; at the same time, they are remarkably scalable and affordable given the wide proliferation of cellular phone infrastructure and consumer devices that incorporate location services, imagers, accelerometers, easy programmability, and connectivity to Web services, social media, and mash-ups. These systems can be leveraged by individuals and communities to explore a range of issues, from endangered ecosystems to chronic disease management and prevention [28].

Project Budburst offers a good example of participatory sensing at work in Gaian IxD. The project is “a network of people across the United States who monitor plants as the seasons change” [29]. The data is used by scientists to track and model changes in seasonal events that may be markers for climate change. Project Budburst has the additional virtue of using not only the CPU of an individual’s computer or the affordances of their mobile devices, but also the “CPU” of the human brain in directing their observations and finding patterns. This is an active form of paying attention that can engage participants in a Gaian perspective.

Project Budburst calls its participants “citizen scientists.” The commonly observed problem with citizen science is the validity of their data. Systems like the Open Mind Initiative [30] address this issue through redundancy, more than one participant making the same observation. Creating complex models requires “everything we’ve got” and then some: more data, better models, more citizen scientists, and better science.

In *The Vanishing Face of Gaia*, Lovelock points out that we do not yet have a good enough model to predict the course of climate change, but that it is hap-

pening more quickly than we imagined just 10 years ago, and that it will continue in fits and starts, not sliding up a smooth hyperbolic curve. We will not be frogs in the cooking pot. And we are racing against time.

But if our models are inadequate, how could gathering more data help? When there is more data, the holes in our hypotheses become more apparent. We see phenomena that a plethora of data cannot explain. In science, holes in hypotheses lead to new questions, new hypotheses, new science—and when we are fortunate—new understanding and new capabilities. In a nutshell, that's why participatory sensing matters, and that's why Gaian IxD should be bearing down on more and better observation—attentiveness—as a method that can be expanded and designed so as to engage more participants at deeper levels.

Take a Stand!

Rain came down where I made my stand
And the cyclone rose with a wave of my hand—Bruce Hornsby [31]

In *The Vanishing Face of Gaia* Lovelock's view has grown pessimistic: "...it seems that climate change can happen faster than we can respond to it, and it may be irreversible" [32]. Many of us grow dispirited and fatalistic; others succumb to denialism fueled by the media Spectacle. Some, like me, believe that hope is the best working hypothesis. Bearing down on Gaian IxD requires hope and courage.

In his *Science in the Capitol* trilogy [33], Kim Stanley Robinson takes the reader to a near future where catastrophic changes are happening suddenly, as Lovelock and others have predicted. In Robinson's three-book series,

the heroes are NSF wonks doing hardcore science and making exceedingly bold choices. There is no time to sit back and ponder the unintended consequences of our urgent efforts to address the unintended consequences of our activities on Earth. These characters are 21st-century heroes.

Although perhaps not as swash-buckling as Robinson's crew, interaction designers can make unique and vital contributions. We can enable and encourage the kind of attentiveness that will feed science and spread Gaian awareness. We can create representational methods that change minds. We can galvanize public will to demand policies and actions that take Gaia seriously. Through Gaian IxD, we can take a consequential stand on what may be the greatest challenge of our day.

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