EDITORS: Bruce D. Campbell, bcampbel01@risd.edu
Francesca Samsel, fsamsel@tacc.utexas.edu

DEPARTMENT: ART ON GRAPHICS

Amy Karle: Artistic Prototyping to Probe the Future

Amy Karle, *Independent Artist, San Francisco, CA, USA*
Bruce D. Campbell, *Rhode Island School of Design, Providence, RI, 02903, USA*
Francesca Samsel, *University of Texas, Austin, TX, 78712, USA*

This article presents an interview with independent artist Amy Karle, whose work explores the intersection between art, design, science, and technology. The interview provides details about Karle's artistic process and how she maintains a commitment to leveraging emergent and exponential technologies to probe fundamental questions of life and create ultra-contemporary artworks that illuminate potential impacts of technology on humanity and the future. The discussion provides insights into the profound understanding she's gained through her work, regarding the intricate relationship between technology and the human experience.

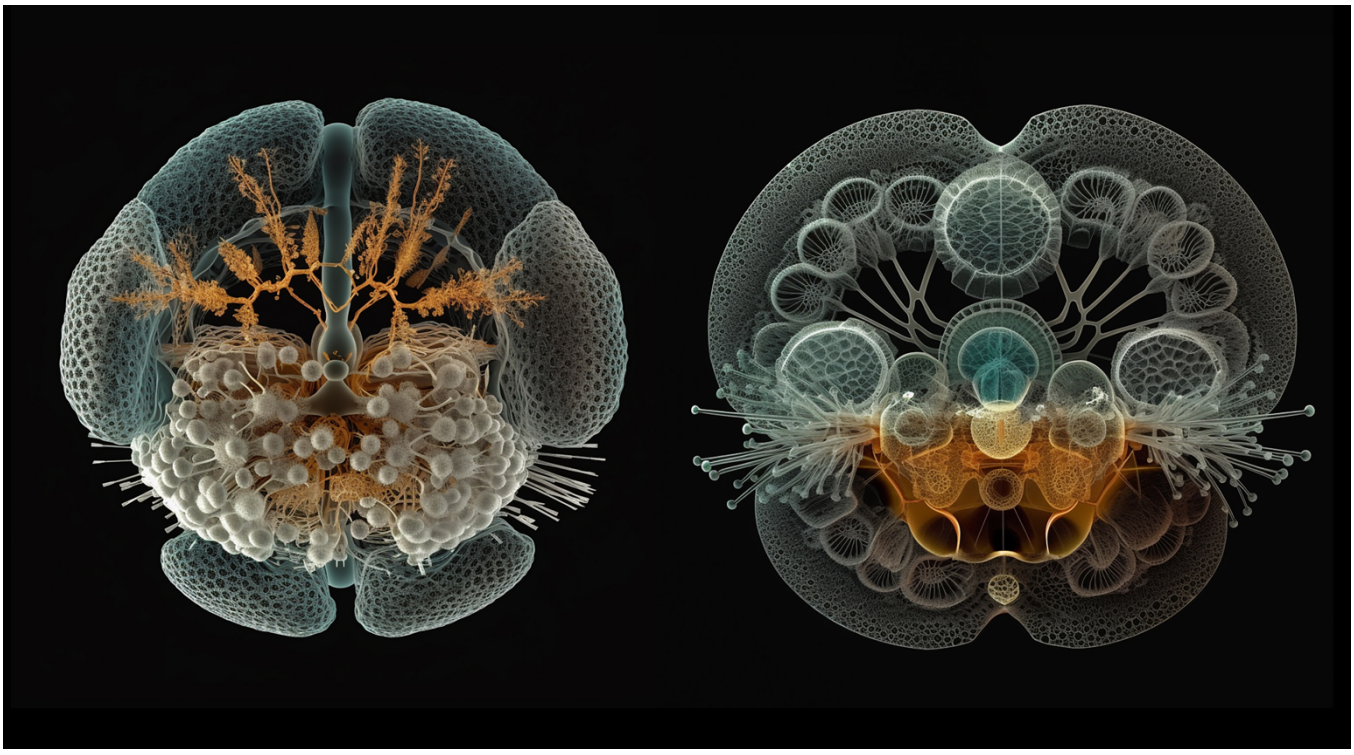

Figure 1 – *BioDigital Organisms*, by Amy Karle, 2023–2025. Synthetic "bio-digital" life-like entities serve as models to study the emergent properties of complex systems, prompting reflection on the nature of life and the potential for new forms of synthetic life within bio-digital ecosystems.

The following interview was conducted by the *IEEE Computer Graphics & Applications* (IEEE CG&A) Art on Graphics department editors via a Zoom video conference on 3 December 2025 with Amy Karle participating from her studio in the San Francisco Bay Area, California.

Amy: Hi.

Bruce: Hi, Amy. Nice to meet you.

Amy: Thank you for inviting me.

Francesca: Nice to have you with us. We are thrilled that can give our audience an overview of your background and the kind of work you do that motivates you (see Figure 1).

Amy: Thank you. I explore questions like “What does it mean to be human?” and “What does it mean to be alive at this time of merging with technology, especially exponential technologies that are changing everything about us and the world around us?” I look at how technologies change us individually, how they change us societally, how they can change the course of evolution. The way that I work is by using the technologies that I’m questioning while I’m researching and making the work. I explore exponential technologies. From AI to biotech, I work through a process of research, and oftentimes, the technology is not established to do what I want to do but is almost there, so new developments are often made in the process that are both technical and scientific. Although my work can be very research intensive and very technical, ultimately, I work as an artist because that is the way that I communicate best. As I’m researching, I’m asking questions: technical questions, emotional questions, philosophical questions, and other fundamental questions. The way that I summarize that all in one moment, one instant, is in a piece of artwork, my research culminates through a critical making aspect.

Francesca: How to you choose what piece of artwork to make?

Amy: I don’t consciously choose that, the work seems to choose to be made through me. I’m researching, and leveraging advancements in science and technology and working through the impacts on our lives and on our world, on the living systems, ecosystems, and the various intelligences that these technologies and tools affect. I’m learning from these intelligences in the process and I like to create a space for collaboration to happen through different disciplines and collaboration with AI. I watch, I step back, and then pursue orchestrating a fertile ground for the artwork to happen.

Francesca: I’m interested in your process and why these feel so unique, especially compared toother AI-generated images.

Amy: Thank you. I work across many different mediums, technologies, programs, and materials, but somehow the work shares a similar aesthetic. It shows up as a mix of organic and generative, parametric forms. A lot of it is biomimicry. I’m looking at how nature forms and grows, how forms come together. I’m not trying to control nature or tell it what to do. I’m trying to create the conditions for it to do what it does well. If we mimic what the spongy part of bone does when it heals and translate that into computational design and 3-D printing, the biology and process begin to dictate the form, and the materials and technology leave a visible signature on it. Part of the aesthetic is natural function, part of it is the merge with science and technology.

Bruce: So you start with an intent.

Amy: Yes, and my intention in creating work is not just to push the technology and the materials forward, but to pursue how we create a healthier future. They're not aesthetic experiments as much as they are philosophical experiments intended to prototype a new way of being. I look at my artwork as artifacts of a speculative future, because I'm thinking about this future and I'm creating these forms in the process and I think it's time to look at an artifact in an environment to experience what this new future could be like.

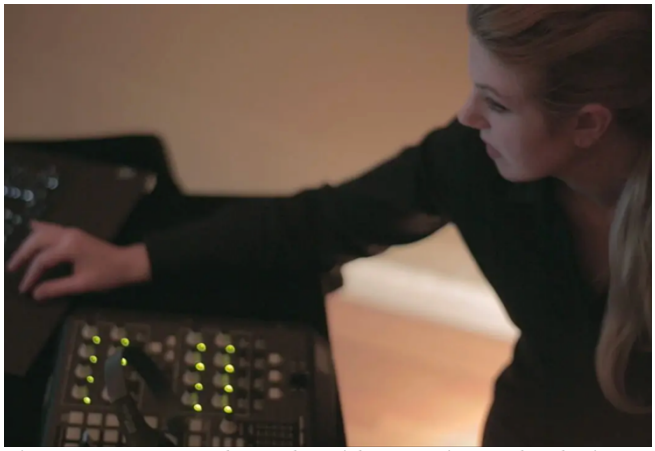

Figure 2 – Amy Karle works with emerging technologies to envision possible futures that use them to heal.

Francesca: But there must be some tangible component to where you begin?

Amy: When I approach my work, I have different methods of working (see Figure 2). In one, I have access to specific tools and technology, and I explore what could

I create with this that wouldn't be possible any other way? How might it be directed toward health, wellbeing, a better future? The technology shapes what emerges. The capabilities, constraints, and implications inform the meaning, the form, the aesthetic, the questions the piece asks. Another method begins when I don't have the technology, but I have a vision forming. I seek out who is doing this kind of work, who might have the technology or be engaged in research that fascinates me, and I reach out to explore if there's an opportunity to collaborate. When we click, a stronger vision comes into focus together. I used these methods as an artist-in-residence at Autodesk, where I had access to incredible software, a digital fabrication lab, a bio-nano lab, and medical software for biological implant design. I used the second when introduced to HP Labs, who provided advanced 3-D printing capabilities. Other collaborations, like Studio Quantum, are even more deeply co-creative, where the research and art evolve together.

Bruce: That distinction makes sense.

Amy: I can find myself somewhere in between the processes, like when there's a commission. My piece *A Pulse in the Stream* was created to open the box of an AI data center, we wanted to reveal more about what goes on inside that's normally hidden, to visualize its systems of computation, energy, and information as an embodied, evolving intelligence engaging with and from the environment, people, and world around it. That's an in-between place where there's a concept for me to work with and a lot of freedom with which to create. Either way, when we work, we almost always have to build up the compute power and modify and enhance technologies to help build out what I want to build. There's a huge customization component in all of my projects.

Francesca: Let's dive into some of the work so that we discuss concrete examples. Could we talk about the *Echoes from the Valley of Existence*?

Amy: *Echoes From the Valley of Existence* is an interactive immersive installation (see Figure 3). The commission came through "The Last Snow" Sapporo International Art Festival in Japan. They asked me to create a piece on the future of death life, 100 years or more in the future in the context of the last snow. I thought, wow, this is like prompting an Amy AI. If only. everybody could give me such a beautiful, poetic prompt. I was thinking about all the traces that we leave behind: our digital traces, our DNA, and other things that we leave every day without thinking about it too much—all the texts we write, all the interactions we have digitally, and all the photos we take. I wondered about how someone will look at that and make up a story about who we were when we lived? I kind of think of it like King Tut's tomb. When we look back and we see Egyptians, they are humans, but they have such a different approach to living. Through them, we learn so much about what it meant to be human at that time. There's still so much we don't know. We put our modern values onto their lives now, so I made the installation and it had responsive elements. There were two screens. On the front screen, I was thinking about a quantum future. I was thinking about, yes, digital, we're really steeped in, but if we also think about a future where quantum technology, quantum computing, and quantum communication are as pervasive as digital technology, what will be the fundamental shifts that occur into this death–life arena? How do we resonate across realms? How do the boundaries between what is living and what is technology dissolve, especially when that kind of technology is based on the fundamental building blocks of everything, of what we're made of, what the world is made of, and how will the veil dissolve? What will we weave of ourselves in that realm?

Figure 3 – *Echoes From the Valley of Existence*, by Amy Karle, 2024. The artwork reflects visitor's bio-digital echoes through real-time body tracking, biometrics, and the mirroring of a person in digital form modified by current environmental conditions. The interactive exhibit offers the opportunity to leave messages and DNA for the future.

Francesca: What does the live audience experience?

Amy: Visitors enter a darkened chamber with two screens that initially read as an eclipse. The space responds to your presence, reflecting your body and biometrics as a ghostly digital image. The front screen represents a quantum future: if quantum computing and communication become as pervasive as digital

technology, how will boundaries between living and technology dissolve? The back screen reflects visitors' echoes through real-time body tracking and biometrics. The technical architecture integrates computer vision, environmental sensing, and generative visual and sonic systems that continuously reconfigure based on participants. Based on Stanford research on the cymatics of heart cells, the sound created a visceral resonance that visitors felt physically, as if the space itself had a portal, where the boundary between their body and the installation had dissolved.1 The sound is based on research done at Stanford on the cymatics of heart cells. Text and imagery appear from0 participants who leave images that were captured there, and they can leave their DNA.

Bruce: Your video shows that effectively.

Amy: Yes, this is what I do with a lot of my artworks. I get to a point where I feel like, okay, this is really great, and most people would stop here, but no, it's not enough because I'm having this engagement in real time. What I'm really trying to think about is for us to have the awareness of how these engagements we're having every day are leaving traces. I remembered the company LifeShip, who was sending DNA to the Moon, and they have both a commercial aspect and a nonprofit aspect that tries to make a kind of backup copy of Earth's DNA of plant and animal species. I contacted them and I said, "would you sponsor this Echoes piece and give people the opportunity to leave their DNA for the future and messages and images for the future?" They said "yes." So as part of this piece, participants left DNA with their text and images and that was put in an archive that currently rests on the Moon.

Francesca: What did your participants think of all this?

Amy: It really made people think: would you leave your text, picture, or DNA? One or the other? Why or why not? This art offered the opportunity to be conscious of that; there are so many things we do that we are not conscious of. Every day we shed data and DNA without thinking. The piece makes that visible. It asks: what if you consciously choose what to leave behind? What would you want to echo into the future? (see Figure 4)

Francesca: What did you find in people's responses?

Amy: First, I'd love to hear your response. Then I'll share some of theirs.

Francesca: That's a really interesting question but it's clear as day to me I'd leave DNA, because I'm connected with this physical world that we live in, and being a physical being, words feel minuscule as anything I would leave behind.

Figure 4 – *Echoes From the Valley of Existence*, by Amy Karle, 2024. Participants can provide their DNA as part of an archive and seed for the future to be embedded on the surface of the moon, prompting contemplation about our place in the universe and how we may echo into the future and cosmos.

Bruce: I don't associate myself with my DNA. I started working with social media commercially in 1992, in a very large insurance company where everybody in the company had access to social media to try and progress the work we were trying to do. It flattened the organization. I developed an etiquette that I thought was good and have taken that etiquette out into the world through to today. I'd love to capture that etiquette in a way to suggest that we weren't all just reactive and responding to everything while being pulled along. Some of us really thought deeply about what was good etiquette for social media and I'd like to leave that behind somehow. That essence of me means a lot more to me than my physical DNA because I haven't felt any control over my DNA. I am a distributed intelligence person and I think that it's the time that you're born into, with a brain that's ready to dive in, ready to respond to what the current day provides.

Amy: There are relevant theories as to why we see that DNA is activated at different times, we carry genes that may remain dormant for generations then get activated by environmental conditions or by the time we're born into. When you say it's the time you're born into that shapes how your brain responds, I love that because it may also be that certain genes are switching on in response to that moment. We see this across species and populations: the

same genetic material, carried for thousands of years, expressing differently depending on conditions.

Bruce: Do you think there's a self-destruct mechanism waiting for us if we go beyond a line?

Amy: I don't know if that's in the DNA, or if that's in the nature of human nature.

Bruce: Human nature will probably get there first. I agree, we can outdo that very quickly.

Amy: Those are the kinds of questions I ask with my work.

Bruce: Nice. What do you get in terms of general trends from what people suggest?

Amy: I can give you some statistics. The installation was open for 37 days. And what was really beautiful about this piece, that I could not have foreseen, was that it opened on the first day the Japanese landed on the moon. It was culturally resonant. And that's something that I appreciate about my works when I do them on site: the cultural aspect that comes into play that I can't foresee, and how I offer my work, and share my work, and then what comes back to it. It's beautiful what I can't foresee. Like the kickoff, it was really nice. It made the cover of WIRED Japan because of that. Well, in part also because of these questions that we were asking. In the course of 37 days, 7,758 messages were left and around 5,600 participants left their DNA.

Francesca: So slightly less people left their DNA than messages. Any other interesting feedback?

Amy: I got a lot of different feedback. People really wanted to leave messages that are meaningful (see Figure 5). What would I want to leave for the future? How do I be a good ancestor? And though I tend to think of this piece as being future forward-facing, one of the most moving stories was when an older Japanese man came to me very emotionally, which is uncommon for that culture to have this kind of interaction, especially with a stranger or younger woman. He explained that he lost his father in one of the wars, and was not himself in the war, so he was not able to give him a proper burial. By leaving his DNA on the moon, he felt like he was able to bury his father. And he felt that deeply. He just knew this was his answer, and it moved me.

Francesca: Your amykarle.com website shows many beautiful examples. Can you talk about the photos on your site?

Amy: A lot of people talk about all the pictures they take in a day, and we agree on how many pictures we save and don't ever look at again, or how we upload to a social media platform and they're saved 28 times in different sizes. Is all of that necessary or important? Is that really what we want to share? What is the most important thing to keep and show for the future? What would we want to show our grandchildren? How do we curate for them? *Echoes* did open up many conversations about what do we leave behind and what is that impact in our space and time, and how that might change when we're looking back upon it in the future. It takes me back again to thoughts of King Tut's tomb.

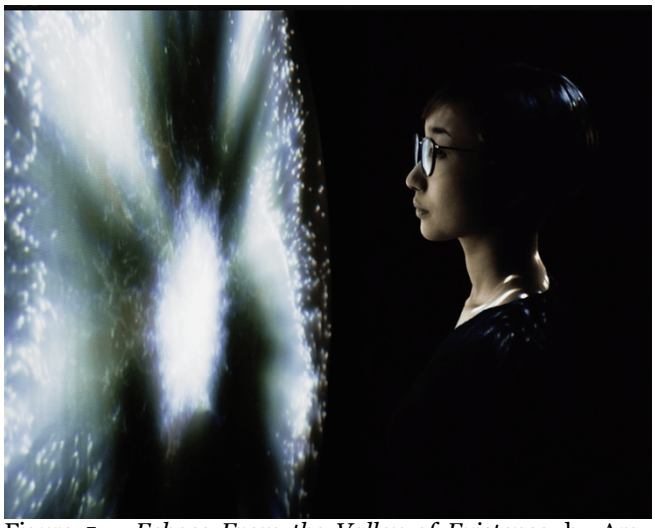

Figure 5 – *Echoes From the Valley of Existence*, by Amy Karle, 2024. The installation navigates the extension of our existence and identity in technological realms, the bio-digital information we leave behind, and what may happen to those remains in the future.

Amy: I think about how amazing that was to open the tomb, but also about the people that got sick from it. We learned so much about humans, but how do we do that in a safe and responsible way. I have a lot of questions because my other bio artworks were not really covering this. I do a lot of work with bio printing and growing living forms from cells from live human donors. I'm not collecting something or harvesting something without anyone's permission, it's always opt-in. However, when I do the bio artwork on Earth, it's not going to affect anyone, it's behind a few layers of glass in a museum. If it is going to be put into somebody's body, then it would go through FDA testing and approval. However, when I'm doing the work in space, it is completely unregulated, with potentials that are not considered. Do we even know the right questions to ask? How do we think across these long timeframes? For me, the practice is the answer: orienting toward potential good, while remaining humble about what we cannot foresee is itself the work. The questioning itself is the contribution.

Francesca: What other piece would you like to share next that has relevance here?

Amy: I can share some of my other pieces that I'm really well known for. *Regenerative Reliquary* was made in 2016—almost 10 years ago. The piece is generatively designed by printed scaffolds that are seated with human stem cells from a living human donor. The idea is that, over time, the scaffold dissolves and the structure triggers stem cells to become bone cells. Stem cells grow into tissue and get mineralized into bone while the scaffold dissolves. This piece is bio artwork, from bio design, and it also doubles as a prototype for patient specific grafts, for when they need a replacement. My story is rooted in that as I was born with a life-threatening birth effect.

Bruce: Do you feel comfortable sharing a bit about that?

Amy: I was missing bone skin and bone on my head, and it was threatening as all the other children that had this kind of defect had died with it before me. But my parents are pharmacist chemists so they brought me home and said, “we're going to take care of her”. Growing up I had a number of experimental surgeries until one worked. I was a teenager when they closed the skin, but my bone is still open. That experience I call my birth effect, not a birth defect, because it really shaped my interest in science and using technology to heal us. Even if the science and technology isn't quite there yet, what can we envision that might heal us and how do we work towards that? Understanding the human condition because of the body, the pain, the suffering, and the things that science and technology can't heal, I want to consider the dynamic between hope and promise and what we have to do as human beings to develop and use it wisely. This kind of work is a really exemplary of me working towards exploring that goal. The success of this piece required a lot of collaborating with scientists and technologists—ultimately collaborating with AI and with cells. This was a very early on, first example of artwork bringing together bio and tech. This is when things get really interesting to merge, like our infotech with our biotech to create something that was never possible before. They had to build up the computing to be able to process roughly three times the number of cells that are in a human hand bone. At that time, to be able to process something like that required immense computing power, and then to bring that from a computing environment to a 3D printer with the materials to try to mimic the spongy part of bone that triggers stem cells to become bone cells. We had to bring together a generative design with a certain kind of AI, with infotech and biotech coming together. It was very, very interesting to see how we can work together, and still to date, as far as I'm aware, this is the largest scaffold that was made for a 3D printed stem cell culture —or for cell culture in general. This was interesting because this is really art and science coming together and complementing each other. Scientists usually work on this stuff on a really small scale in the lab.

Bruce: What scale is that?

Amy: A millimeter at the microscopic level, but as an artist I want something that's immediately recognizable as human in a museum (see Figure 6). A full-scale hand because, with bones in the human body, we maybe recognize skulls and hands or feet to know what is human. We have to build up the power of the technology with the materials to be able to achieve that.

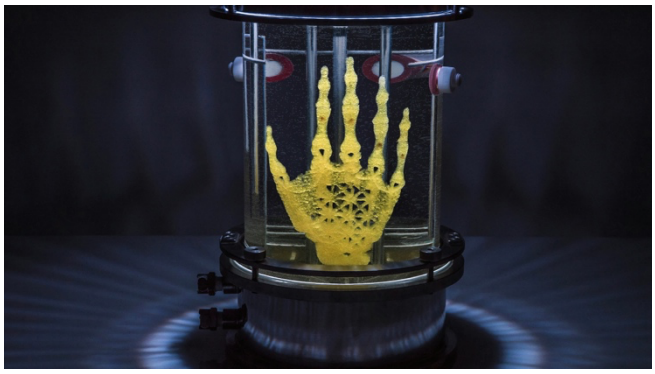

Figure 6 – *Regenerative Reliquary* by Amy Karle, 2016. A bioprinted scaffold in the shape of a human hand design, 3D printed in a biodegradable pegda hydrogel that disintegrates over time, leverages the intelligence of human stem cells.

Francesca: Can we talk about your *Golden Archive* piece like (see Figure 7) and how it morphed from your bio work and emotional considerations?

Amy: Yes. We’re discussing how I engage in critical research and creative practice by using tech tools and prompt-based questions. I watch, step back, and watch to orchestrate the fertile ground for that to happen. My intention in creating work is to push the technology, materials, and processes forward, but also to consider the big vision and ask these really fundamental questions about how we create a healthier future. I really look at these works not as aesthetic experiments, but as philosophical experiments, and they prototype new ways of being. I look at my artwork as artifacts of a speculative future, because I’m thinking about the future and I’m creating these forms in the process. I think it’s time to kind of look at these pieces as artifacts or environments to experience what this new future could be like.

In that train of thought, the *Golden Archive*, follows upon the *Echoes From the Valley of Existence*. I'm asking these kinds of questions that I think are on a lot of people's minds about what we are doing in space. Are we just randomly throwing things up there? What is important to leave? This is a sacred expanse. How do we treat it with that regard? I'm asking philosophical questions that people are not necessarily asking when working in that arena. I was asking these kinds of questions that I think should be on a lot of people's minds, and I have the freedom to be able to explore that as an independent researcher. I'm an independent artist. As part of that, I was invited to create the cover art and then ultimately also be a partner on the *Golden Archive*, which is a new version of the Golden Records, 50 years after they were sent into space. What is the essence of the Golden Records that we want to preserve? What is the idea that we want to bring forward? What are the advancements that we've made in 50 years that we want to include? What have we learned? Very interestingly, DNA is one of these elements, so this new version includes a vast companion of human knowledge and culture compared to the last one. We can include a lot more now that it is on the nanofiche. There's DNA from many species, including humans. There are seeds. DNA to me is the most intelligent thing that we can share because it's not a representation of the thing. For many artifacts, you've got to figure out what it represents in order to figure out what it is. DNA is the thing itself. I love that, and this is a trajectory that I'm exploring more with my work in space: what is representative of the thing itself? The original Golden Records carry uranium-238 as a radioactive clock, letting its own decay mark time, not writing about something in a language. This is very interesting. This is like the thing itself. Then, this new version also includes a language model, which is also interesting.

We can show animated tectonics and have different things change and then bring on the humans. However, how do I represent all species, or all cultures of humans? If I use a male and female, then that's so heteronormative, and you know these are impossible projects in a lot of ways. We have to try to do our best and I also only had a month to do it, which was actually what the original Golden Records folks were given. Representation is an impossible design problem. Even in the imagery, we are designing for the assumption of sight or visual interpretation. We knew we wanted to depict Earth, and humans... and how do I represent all cultures, all bodies, in two people? What part of the Earth do I show? This is really hard, but we have to do our best, and we stay accountable to what our choices include and exclude. Designing for finders we cannot imagine, whose senses and knowledge we can't predict. That's the design challenge I'm drawn to: how do you communicate with someone you'll never know and what is important to share? The original Golden Record carries uranium-238 as a radioactive clock, letting its own decay mark time, not writing about something in a language. In this case DNA is also not a metaphor or depiction, it is executable biological information, a medium that carries agency across time. It makes archiving less about describing life and more about transmitting the conditions of life. It is a materially consequential payload, and changes the ethical burden of what we send, and it also is perhaps one of the most valuable things we can send. That tension is part of the point. I want to keep asking better and harder questions, while staying responsible about what it means to engage across space and time.

The work brings up all kinds of questions and I'm much more prepared now for a next version. I am already working on the next version with Interstellar Foundation, because I think about how this is made for something, which has eyes and senses like we have. I'm looking at future versions of what would be interaction designs we know about, if it crashes into something. The philosophical questions are interesting with this impossible project on Corning billion-year materials, which is mind blowing. I don't know how they test that but it's billion-year materials. I love Corning and I trust their work. It potentially outlasts us to be like a backup copy of us in some ways. What is important to capture is like the fundamental questions I'm asking with Echoes From the Valley. What is important to save, what is important to capture, and what is important to communicate? I am also thinking about DNA and one theory of how life on Earth started when a meteorite crashed here. That the meteorite had the right DNA, in the right condition, to crash into the right conditions and spawn new life. However, then it can alternatively crash into an ecosystem and wreak havoc on it, and we don't know how DNA changes as it's going through space and time. I continue to ask questions, and I always want to be asking better and harder questions, while still doing my best all the time.

Separately, my "A Retrospective for the Future" became the first artist retrospective ever placed on the lunar surface, launched with NASA, SpaceX, Interstellar Foundation, and Lonestar Lunar, encapsulating over two decades of my work, asking questions about who we may become with our science and technology and incubating for the future.

Francesca: Any other work you want to highlight with us?

Amy: Yes. I want to briefly mention a piece called *Biodigital Organisms* (see Figure 1).

Francesca: The *BioDigital Organisms* are so beautiful. I don't usually see AI generated art like that.

Amy: I pursued it with a desire to give a biodigital model the same kind of weight as we give business models and other tech developments, because then we are going to have much more potential to get towards those preferred futures. With *Biodigital Organisms*, this was one of a number of artworks where I'm looking at how we use technologies to project into our future and see what changes we're making at this time. Sometimes we are not so consciously aware of how that will affect our future. The biodigital organisms are really fun. They provide AI information about how lifelike entities evolve. But this time we're involving entities in silicon and a computational environment with lifelike behaviors, including growth, interaction, and adaptation. They start to challenge definitions of what's alive and intelligent, especially if we can bring some of this into the lab and merge the infotech and biotech to get living cells, steered by or made in the ecosystem around the computational and digital environment. How does this all work together? With a prototype, we can probe what happens when artificial life can emerge and evolve in silicon, and what role such life may play in ecosystems. And then it makes you really question what role the technology has to start to play in those ecosystems. It leads to a very literal interpretation that says, "look, this is exactly how it affects biological entities", this demarcation between what's natural and what's synthetic is really illuminating that, but we're doing this infused with our technologies in this kind of way and we're not consciously thinking about what the impact is across our time now to future times. I think this is one of the projects that really illuminates that.

Francesca: And then to think about how I see you considering dark technology. This is a thread I see through all of your work. It's about what are the questions of our time, the responsibilities of our time, and how do we reflect on those, and that the work is a conduit for those conversations.

Amy: Exactly. I feel that is fundamentally important across all of our work, for any field we work in, especially for working with technology because, as we're using our technology, we're also developing our technology, and we're shaping that future. If we can be more conscious of it—especially with algorithms running on high powered computing that works faster than we can think—we can consider how it shapes our society and our culture and our bodies and our health faster than we can perceive. We need to be consciously thinking about it and designing for that.

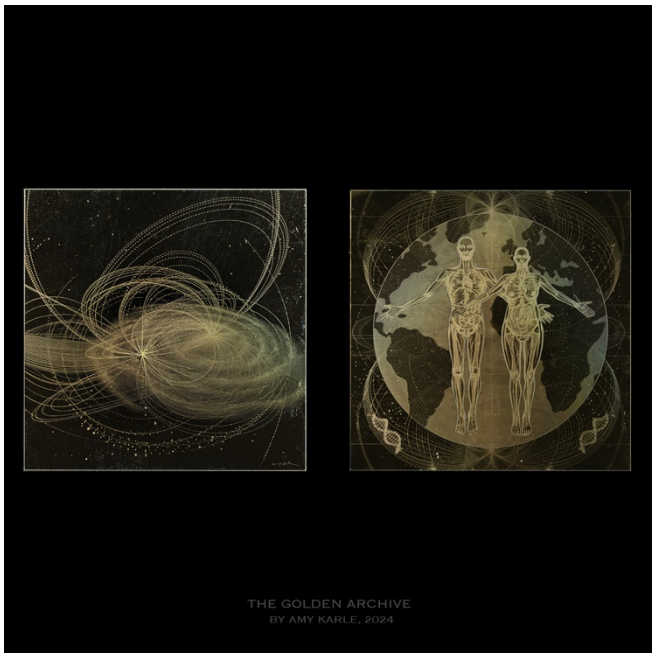

Figure 7 – The *Golden Archive*, by Amy Karle, 2023-2024. An updated comprehensive repository, including records of Earth's biosphere, is a compendium of human knowledge and culture, DNA, a seed bank, and an AI LLM.

I've been giving myself space to dream a bigger dream. As our technology advances, the categories between biological and digital, between computation and consciousness, dissolve more and more. My intention is to continue asking how computing participates in the evolution of life and meaning. If we treat our tools, our archives, our data sets as collaborators in the process of life rather than utilities to be exploited, then every data set, every visualization, every simulation becomes a place where we can choose our future. For the long term I'm working on how do I create systems, art and intelligence architectures, that continue to evolve, participate, and contribute in the way I feel I can add value to the world, even after I'm gone? I hope to one day haunt a machine.

Francesca: That's a good place to wrap up. Thank you, Amy.

Bruce: Yes, thank you.

About the Authors

Amy Karle is an independent artist-researcher based in the San Francisco Bay Area, CA, USA. A BBC 100 Women, and former U.S. State Department Artist Diplomat, her work explores what it means to be human at this time of merging with technology. She partners with forward-thinking organizations and companies to create unique, boundary-pushing collaborations and commissions that result in impactful, inspiring, and groundbreaking outcomes. Her work has been exhibited worldwide (www.amykarle.com).
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Bruce Campbell is a faculty member of Web Design + Interactivity at the Rhode Island School of Design. He received his PhD in Systems Engineering from the University of Washington. His research interests include ocean data visualization and procedural design. Contact him at bcampbel01@risd.edu.

Francesca Samsel is a research scientist at the Texas Advanced Computing Center at the University of Texas at Austin. Her work focuses on humanizing the communication of scientific climate data by integrating the languages of the arts and humanities. Contact her at fsamsel@tacc.utexas.edu.