

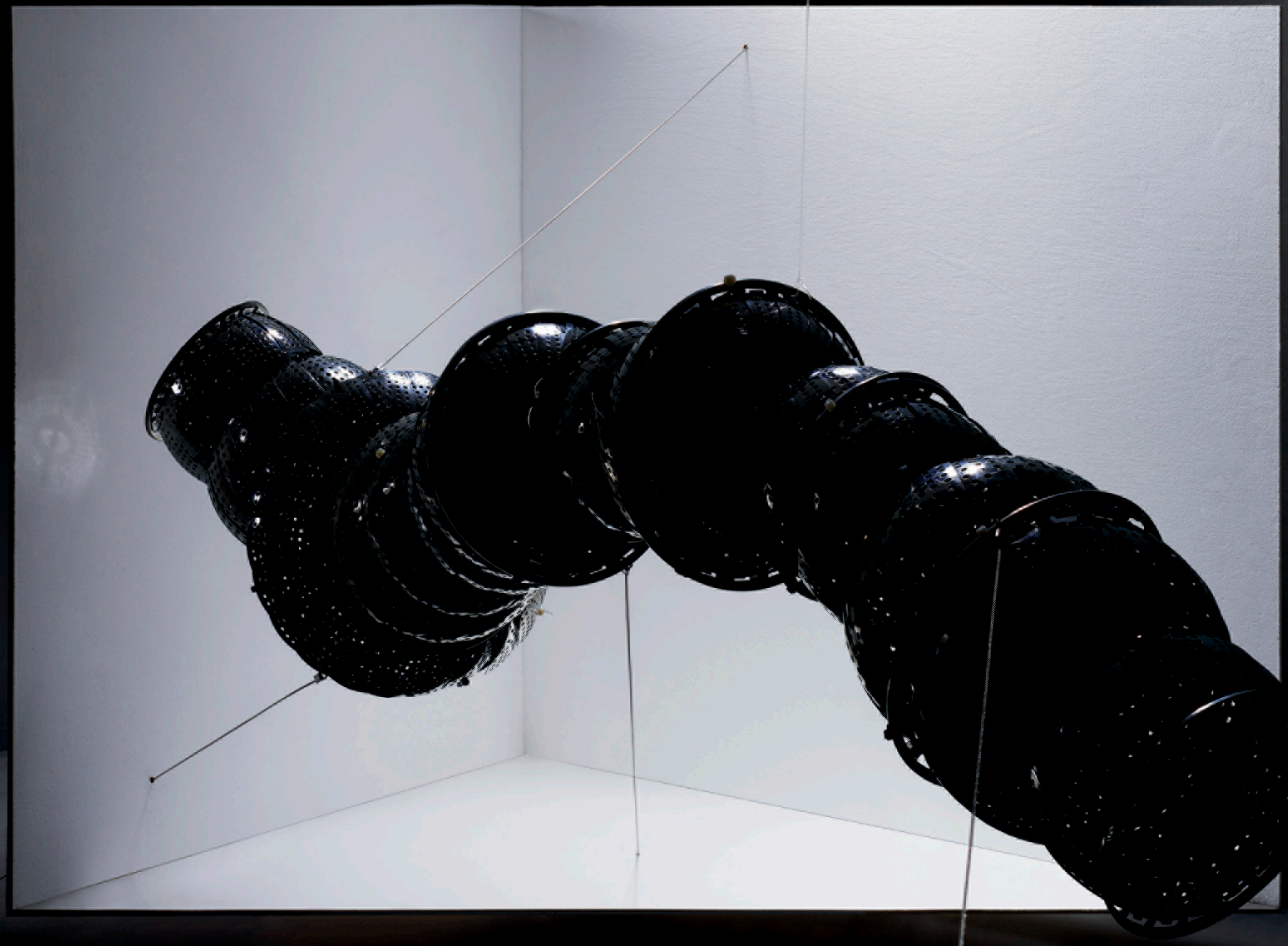
Is Anybody Out There?

In a new frontier called space archaeology, astronomers search the cosmos for remnants of lost life. Abraham Loeb, the man who coined the phrase and leads the astronomy department at Harvard University, wants to know:

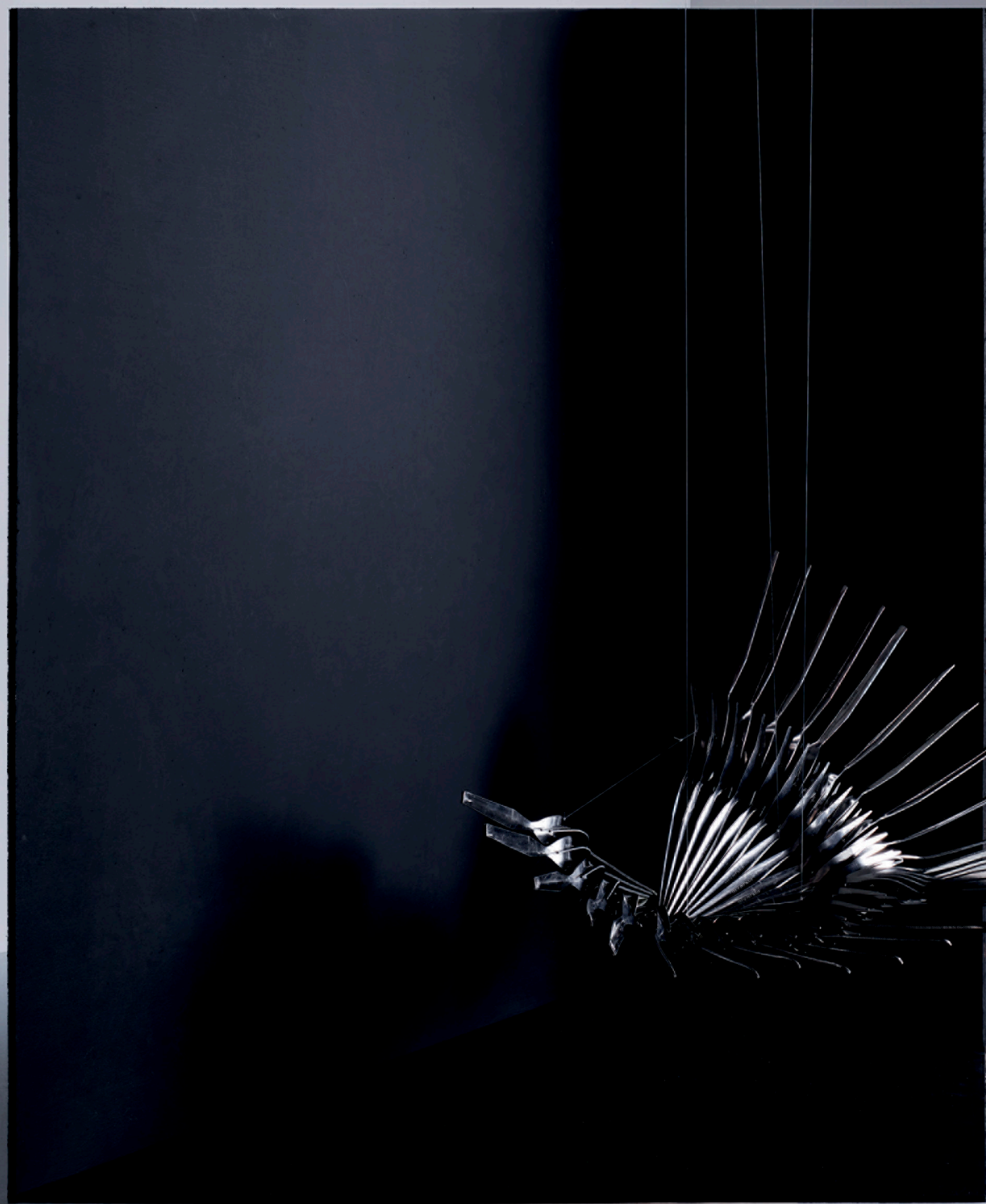
What can we learn
from the collapse of
other civilizations?



Photographs by Dan Tobin Smith







Words by Abraham Loeb

The famous Drake equation quantifies our chances of detecting a light signal from an advanced civilization in space. However, it misses a crucial possibility: Most technological civilizations that ever existed might be dead by now.

There are two obvious reasons to suspect that this might indeed be the case. First, as soon as we humans had mastered advanced technologies, we also developed the means of our own destruction through catastrophic nuclear, biological, or chemical wars, or through a global change in our habitat. Second, recent data from the Kepler satellite implies that about a quarter of all stars host a habitable, Earth-like planet. This naturally reinforces a paradox formulated in 1950 by the physicist Enrico Fermi. At a lunch discussion about the likelihood that our civilization might not be alone, he asked, “Where is everybody?” The simplest answer might be: dead.

But this does not mean that we cannot prove that other civilizations existed. On Earth, we find evidence for ancient cultures that are not around anymore through the artifacts they left behind. Similar to the work of archaeologists who dig in the ground, astronomers can search for technological civilizations by digging in space. I label this research activity “space archaeology.” What might we expect to find?

It is prudent to start the search in our backyard and look for technological equipment floating through the solar system. We might discover artificial objects that originated from other stars, since in the first century of our own technological revolution, we have already sent Voyager 1 and 2 out of our solar system.

The simplest way to detect alien equipment is through its reflection of sunlight, namely by searching under the nearest lamppost, the Sun. The first object that originated outside our solar system detected this way (and the very first interstellar object to be identified in our solar system) was ‘Oumuamua. This estimated 100-meter object demonstrated weird properties, such as an extreme geometry—most likely pancake-like—an excess push without a cometary tail or spin change, an unusually shiny surface, and an unlikely low speed relative to the local population of stars.

Another approach is to use the Earth’s atmosphere as a detector and search for artificial meteors. This would

be technological equipment that collides with the Earth at a high speed—indicating that it was not gravitationally bound to the Sun—and is detected as it burns up in the Earth’s atmosphere. If the object were bigger than a few meters, it might leave behind a remnant meteorite, providing the best opportunity for us to put our hands around alien equipment.

Similarly, we can search the surface of the Moon for extraterrestrial technological debris that may have crashed on it. Since the Moon has no atmosphere or geological activity, it keeps a record of all objects that crashed on its surface, like a museum that is billions of years old. We could find traces of technological equipment that crashed on the lunar surface a billion years ago like a letter from an alien civilization saying, “We exist.” Without checking our mailbox, we would never know that such a message had arrived.

In the above examples, the Moon and the Earth serve as fishing nets to retrieve interstellar debris. In addition, Jupiter could serve as a gravitational fishing net, trapping interstellar objects that pass nearby. Most of the time, we might recover natural rocks or icy bodies like asteroids or comets. But perhaps not always.

Extending the search to the outskirts of the solar system, we can look for artificial lights that originate from giant spacecrafts. A city like Tokyo could potentially be detected with the Hubble Space Telescope out to the Kuiper belt. An artificial source of light can be distinguished from an object reflecting sunlight by the way it dims as it recedes away from us.

The future promises great advances in discovering new interstellar objects in the solar system with the advent of the Large Synoptic Survey Telescope (LSST), which will be far more sensitive than any previous survey telescope, including Pan STARRS, the telescope that discovered ‘Oumuamua.

Venturing beyond the solar system, we could search for artificial light or heat redistribution on the surface of a planet. The nearest star to the Sun is the dwarf star Proxima Centauri, whose mass is only 12 percent that of the Sun. The habitable zone around this faint star is 20 times closer than the Earth-Sun separation. As it turns out, our neighboring star hosts an Earth-size rocky planet, Proxima Centauri b, at that distance. But since this planet is so close to its sun, it is likely tidally locked, like

the Moon to the Earth, so it faces the star with the same side at all times. Naturally, the permanent dayside would be hot and bright whereas the permanent nightside would be cold and dark. But an advanced civilization might attempt to cover the dayside surface with photo-voltaic cells, generating electricity to artificially illuminate and warm the nightside. As the planet moves around the star, the varying level of light from its surface could inform us whether a global engineering project of this type took place. We could also search for the unusual reflectance and color we would expect from solar cells on the dayside. These studies could be done just by monitoring the planet’s light and color as it moves around the star without any need to image its surface.

But artificial activities may have other consequences, such as industrial pollution of atmospheres. The contamination by a blanket of pollutants or aerosols may be intentional in order to warm up a planet that is otherwise too cold. Our archaeological dig could include a search for artificial molecules, such as chlorofluorocarbons (CFCs). Some molecules and surface effects may survive long after the industrial civilization that produced them had died.

At even greater distances, stretching out to the edge of the universe, we could search for flashes of light from beams sweeping across the sky. Such beams may be used for communication or propulsion purposes. In particular, spacecraft launch systems based on the technology of light sails would inevitably appear as flashes in the sky, due to the leakage of light over the edge of their sails when the beam is pointed in our direction for a brief moment in time. Whereas radio frequencies are ideal for transporting massive cargos at modest speeds between nearby planets such as Earth and Mars, infrared or optical lasers are optimal for launching lightweight probes to the speed of light, as envisioned by the Breakthrough Starshot project, whose scientific advisory committee I chair.

In addition, we could search for a swarm of satellites or megastructures that block a significant fraction of the light from distant stars, as envisioned by Freeman Dyson. However, such gigantic megastructures may be rare or non-existent as they face major engineering challenges.

If we recover anything artificial through our archaeological dig into space, the natural question to ask is: Are we the smartest kids on the block? If the answer is no, we could learn a lot from our findings and perhaps shortcut our own evolution by thousands, millions, or maybe even billions of years.

It is difficult to avoid the thought that our intelligence bar would not be difficult to surpass. We fight among ourselves in “lose-lose” situations, we favor short-term manipulations over long-term benefits, and we have been carelessly broadcasting our existence to the entire Milky Way galaxy in radio waves for over a century without worrying about any predators in outer space. One might even wonder whether we have simply been ignored by predators because we appear so incompetent. But as far as space archaeology is concerned, the key challenge to improving our awareness of other civilizations is whether we are intelligent enough to adequately interpret their products.

Our discovery of a piece of advanced technological equipment developed by an extraterrestrial intelligence may resemble an imaginary encounter of an ancient cave people with a modern cell phone. At first, they would interpret the phone as a shiny rock without realizing that it is a communication device.

One fact is clear: If we assign a zero probability for finding evidence for artificial objects, as some scientists did in the case of ‘Oumuamua, then we will indeed never find any evidence for aliens.

How can our civilization mature? The same way kids do, by leaving home, meeting others, and comparing notes with them. In other words, we can develop a balanced perspective on our current technological accomplishments by searching for relics of extraterrestrial intelligence. Since our own technological development accelerates exponentially, it is difficult to imagine the face of a much more advanced technology crafted by a civilization that had lived for a cosmic time-scale.

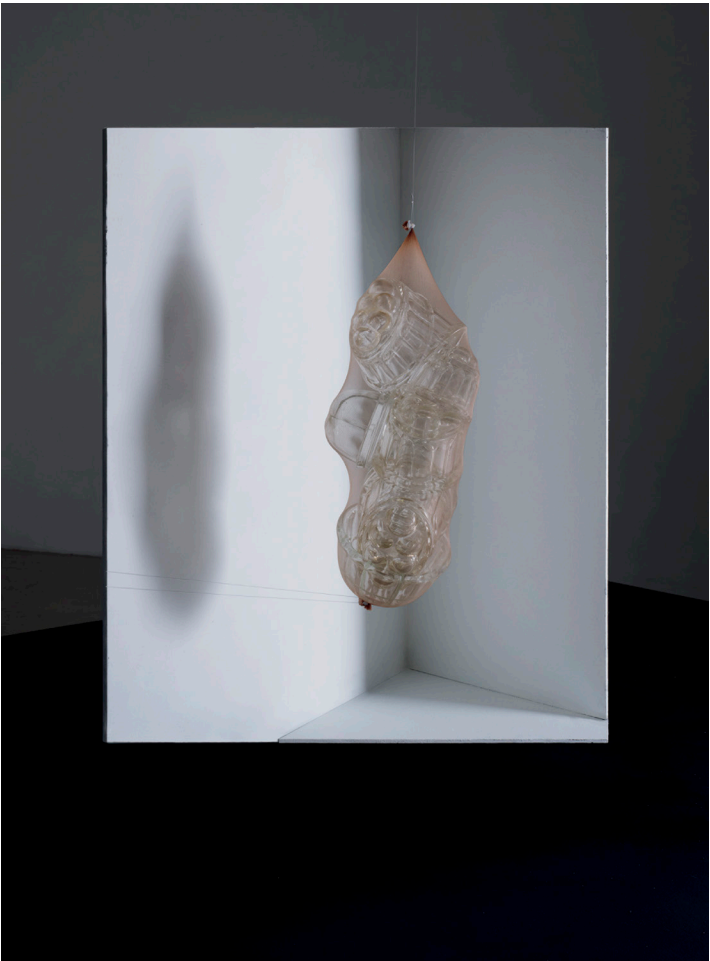
Currently, we keep all our eggs in one basket, the Earth, making it vulnerable to a catastrophe. There is no doubt that we will eventually migrate into space to produce multiple copies of what we hold dear and increase the longevity of our civilization. Just as ancient civilizations migrated toward banks of rivers on Earth, advanced technological civilizations might be migrating throughout the universe toward environments rich in resources, such as clusters of galaxies.

To move forward we must think outside of the box and avoid prejudice about what we expect to find based on past experience.

Young people often imagine new worlds, but their revolutionary ideas are met with skepticism and dismissal by the “adults in the room” who lost their enthusiasm for challenging reality in many bruising fights long ago. The “adults” simply got used to accepting what is known and ignoring the unknown. Youth is not a matter of biological age but of attitude. It means being willing to open up new frontiers of scientific discovery, like space archaeology, rather than staying with the traditional ones.

Becoming a scientist offers the great privilege of maintaining our childhood curiosity and questioning unjustified notions. It is commonly believed in the conservative scientific community that intelligent life may be unique to Earth and that it would be a waste of funds to search for artificial signals in the sky or space debris of dead civilizations in outer space. But this notion should be challenged. Today’s new generation of researchers has access to telescopes that could turn this notion on its head. Just as Copernicus revolutionized the prevailing dogma about our place in the universe, our generation may foster a new Copernican Revolution.

Finding traces of civilizations that died from self-inflicted wounds, such as wars or climate change, might convince us to get our act together and avoid a similar fate. But it would be even more remarkable if flyby photography of an interstellar relic within the solar system revealed an advanced technology never witnessed before. No lesson is more valuable than the sense of awe and modesty that would accompany such a discovery.



SET DESIGN LISA JAHOVIC