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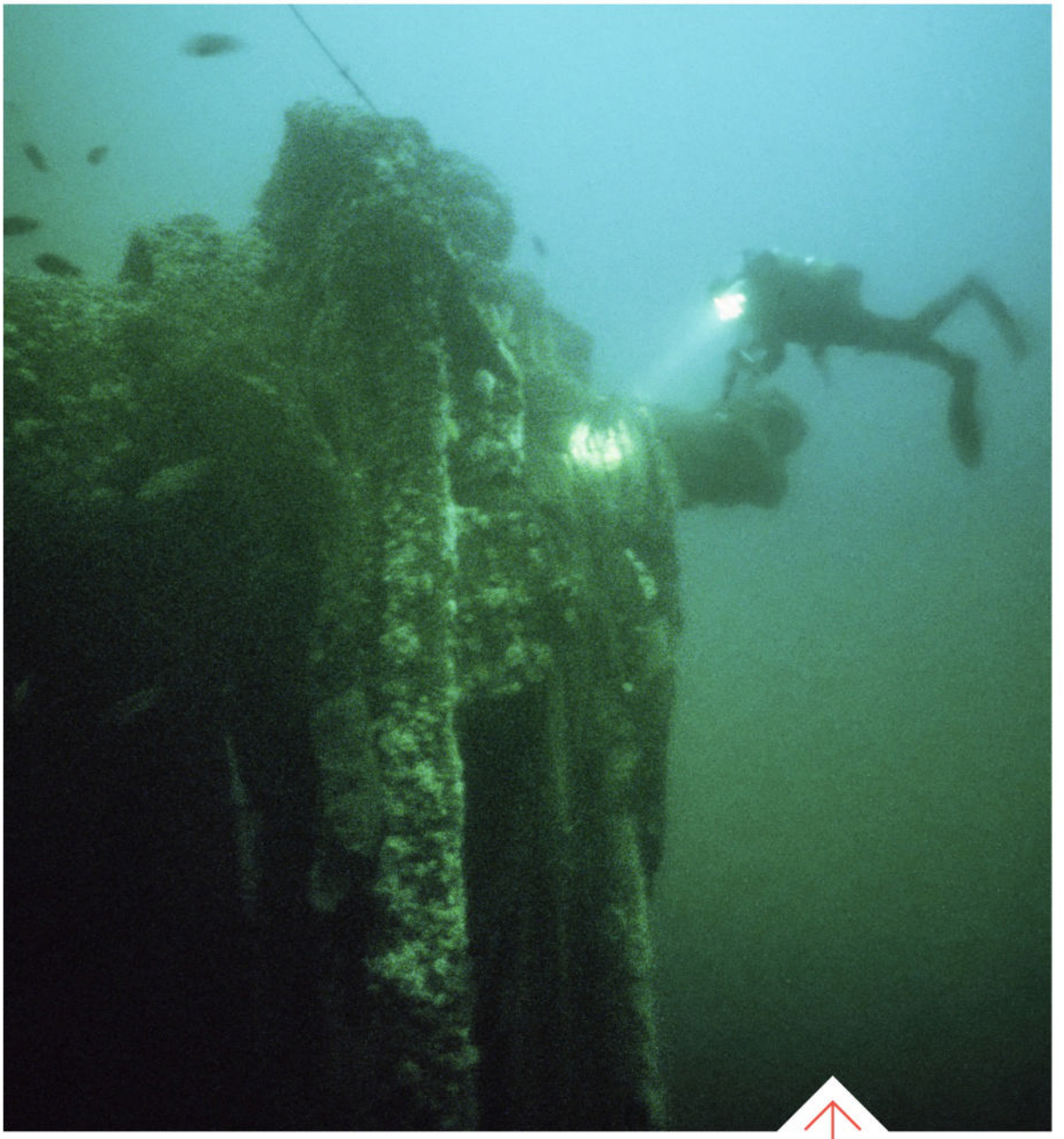
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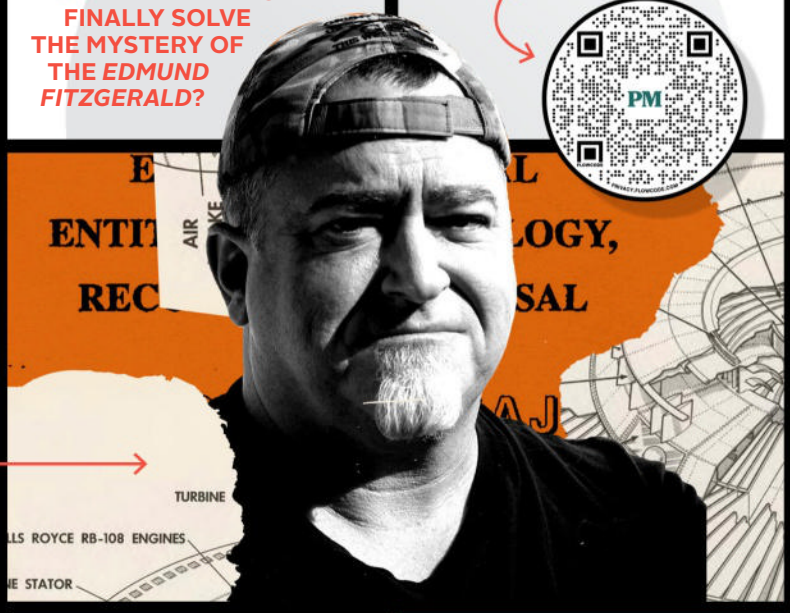
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UFO: MARK HARRIS; TERRACOTTA: GETTY IMAGES/ISTOCKPHOTO

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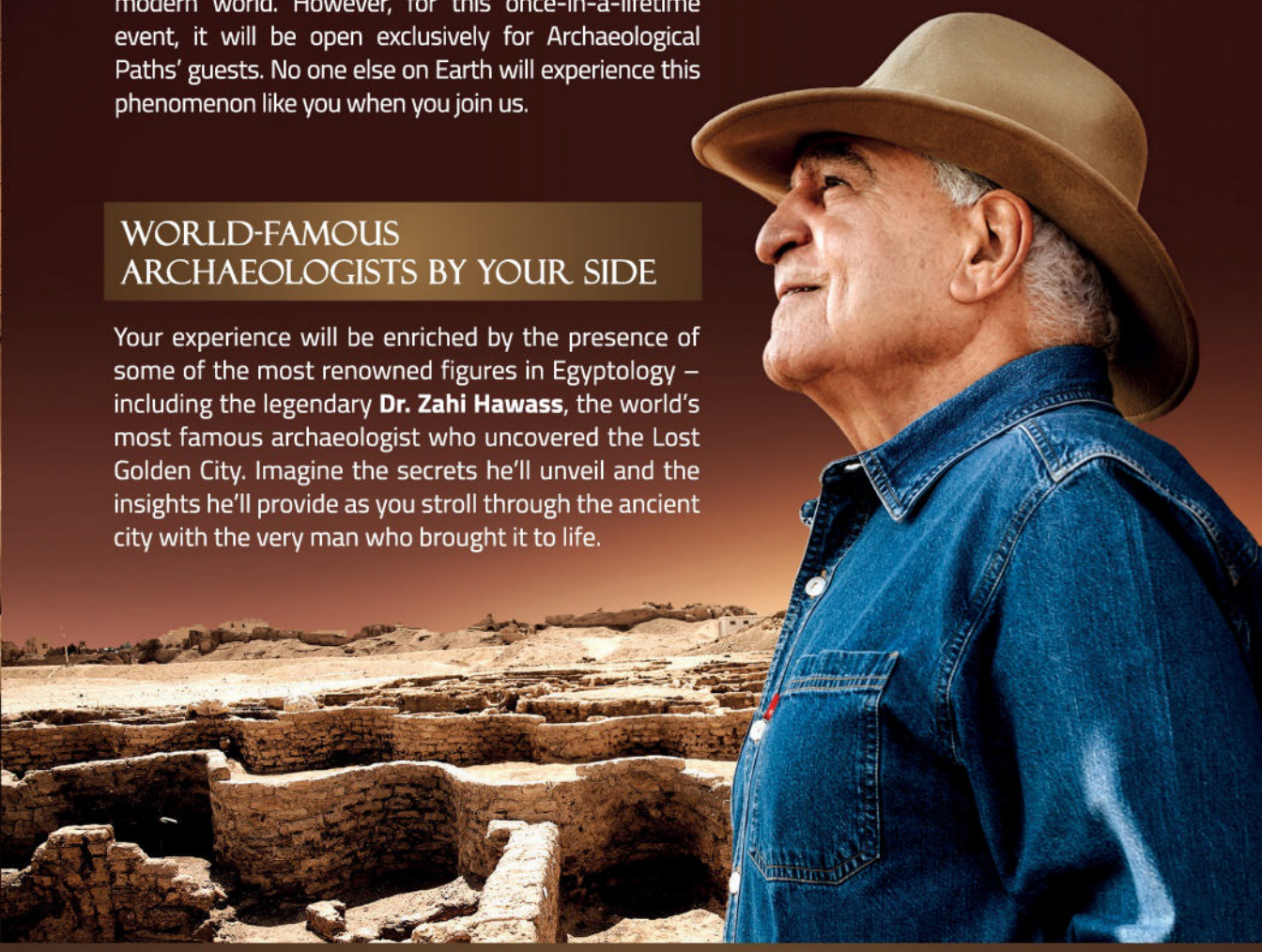
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WHY PILOT HOLES ARE DIY HEROES / P.11

PHOTOGRAPHY BY TREVOR RAAB



SHOULD I USE THE SELF-CLEANING FUNCTION?

The self-cleaning function is fairly self-explanatory. Your oven will lock, heat up to around 900 degrees Fahrenheit, and burn off any bits or other debris before beginning to cool down and unlocking when it reaches an appropriate temperature. Generally, this makes the cleaning process far easier, but if you have sitting grease in your oven, do not use the self-cleaning function; in rare cases, this can cause flare-ups or even start a fire.

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HOW TO

CLEAN YOUR OVEN

Without regular maintenance, baked-on residue inside an oven can produce smoke or unpleasant odors, and even affect the flavor of food. Because of this, many appliance experts recommend periodic deep cleaning—usually every few months, depending on usage—to prevent grease accumulation and maintain proper oven performance.

HERE'S THE BASIC PROCESS FOR CLEANING YOUR OVEN / Remove the oven racks. Sprinkle baking soda throughout the oven, or at least the areas with significant staining. It should be enough baking soda to cover everything, but not too much that it begins to pile up.

Prepare a spray bottle full of either water or a 3:1 water to white vinegar solution. Spray the liquid throughout the baking soda–covered areas. You should see almost immediate foaming if you used vinegar. Allow the liquid to sit for at least 20 minutes, up to an hour.

Put on dish gloves if you don't want your hands to get dirty. Grab some paper towels and begin wiping up the foamy areas. You should see the stains coming up with it. (You may also want to buy a set of scrubbing brushes for tougher spots.) Work your way through the oven, cleaning up as much of the mixture as possible.

Use the same water or vinegar solution you used at the start to give the oven a final wipe-down. The interior should look as good as new.

For stuck-on stains, you may need to repeat the process with something stronger than baking soda and vinegar, such as a degreaser (we recommend Method's Heavy Duty Degreaser).—*Sarah Connor and Geoff Nudelman*



WHY A PILOT HOLE WILL SAVE YOUR NEXT DIY PROJECT

Let's say you're building a bookshelf and you need to screw together two pieces of soft wood, like pine. You've got the screw in one hand and a cordless drill in the other. The boards are ready for fastening. But a little voice in your head tells you that the wood is going to split—and that you'll spend the next 10 minutes fixing a mistake you saw coming a mile away.

Listen to that instinct; wood has a way of enforcing the laws of physics whether you like it or not. Screws act like wedges, forcing wood fibers apart. A pilot hole removes material and relieves destructive stress, so you should always take a moment to drill one. Swap in a smaller drill bit so that the pilot hole is smaller than the diameter of your fastener. That detail is important—anything the same size or larger in diameter will obviously cause the fastener to fail in its bite, rendering it useless.

Fastening wood by hand with a hammer and nail? You still need a pilot hole, and luckily there's an easy hack for that, too. Flip the nail around and tap the nail head against the wood first to blunt it slightly. A duller point actually splits wood less because it crushes fibers instead of wedging them apart. Do this against the framing lumber, and the nail head leaves an indentation for holding the nail in place when you drive it.—*Paul Smith*

BE A GOOD NEIGHBOR.

MEASURE HOW LOUD YOUR GENERATOR IS

While it isn't possible to measure the noise levels of a generator before you buy it, knowing how to do it yourself comes in handy if you're trying to assess the noise level in a new location. In some instances, your generator may be unusable if the model exceeds noise-level rules set forth by local ordinances, RV parks, or campgrounds. A proper measurement gives you the information you need to (relatively) easily relocate your generator to comply with the rules or just be a more considerate neighbor.

It would be really nice if manufacturers simply listed decibel ratings on their product specs, but unfortunately, there's no official testing standard that companies like Generac, Honda, and Pulsar consistently use. Here's how to do it yourself.

Before you start, check to see if there is any loud machinery running in the vicinity, as this could contribute to an inaccurate result.

Use a sound meter (most accurate) or else a sound meter app for your mobile phone.

Position the meter at least 20 feet from the generator (or a distance that's identified by local rules), several feet from the ground (the seat of a folding chair or stool is a good height).

Start up your generator and then plug in the items you would expect to typically run on it so you can get an accurate reading based on the typical power load you would be drawing. If connecting to a manual transfer switch, turn on everything in the house that you would expect to be powering with the generator.

Then take the reading to get your decibel rating.—*David Dristas*





OUR 9 FAVORITE HOME GENERATORS, TESTED



AVOID THIS COMMON PRESSURE WASHER MISTAKE

Improper startup and sloppy technique can destroy a pressure washer's pump, damage surfaces, and cost you more than the actual machine itself. I learned that the hard way when I loaned my neighbor my pressure washer and two hours later, he returned it—completely inoperable. But the fault was my own. I automatically assumed that he knew that running a pressure washer without the water turned on would do fast damage, as the mechanics within the pump can begin to fail in as little as 30 seconds.

Most residential pressure washers use an axial cam pump. Inside that pump, small pistons cycle rapidly, building pressure as water flows through the system. That water doesn't just get pressurized—it does double duty as it cools and lubricates internal seals and packings.

When the pump runs without water, friction and heat build almost immediately. With no coolant moving through the housing, temperature spikes, seals deform, and internal components can score or warp.

That's why it's so crucial to understand the machine and the process before you pull the cord. Here's my order of operations:

- Fill up with top-tier gas (if so powered) and check oil levels. Top off accordingly.
- Connect the hose to the pressure washer.
- Connect all spray hoses to the machine.
- Set up and connect the wand to the supply hose.
- Choose and install the appropriate spray tip to the wand (or soap dispenser).
- Turn on the water to the machine.
- Squeeze the trigger on the wand handle to purge air and confirm low-pressure flow from the house.
- Start the engine.—*P.S.*



6 TIPS TO

KEEP YOUR CONTRACTOR HAPPY

In my experience as a contractor, I've always looked at the opportunity to work in someone else's home as a huge honor. Clients and contractors have a unique relationship which, when the stars line up, can be mutually beneficial to both for years. Get off on the right foot with these preliminary steps to cultivate the best possible home improvement experience.

Clear any potential work areas before a plumber arrives, especially below kitchen and bathroom sinks. If prolonged work is expected, move items to a temporary location to keep children, pets, and surroundings safe from accidental exposure.

Trim overgrown trees that would otherwise inhibit or endanger exterior painters during their course of work.

Relocate grills, patio furniture, and lawn lighting prior to any new roofing project. Reusable tarps or breathable plant covers make cleanup easier and help protect furniture and shrubs from falling debris.

Pick up after your dogs before a scheduled workday or lawn cutting. I know lawn maintenance contractors who add a surcharge if they're working in what they deem a "minefield."

It's best to keep pets elsewhere in the house if that's a viable option. A simple pet gate or portable playpen can keep curious dogs safely out of the work zone.

Maintain a clear path to your electrical panel at all times, especially if you need to call in an electrician for repair work. Labeled storage bins and wall-mounted organizers can keep utility rooms tidy and ensure electricians can get in and out without delays.—*P.S.*

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The handle is made from genuine natural bone, and features decorative wood spacers and a hand-carved motif of two overlapping feathers— a reminder for you to respect and connect with the natural world.

This fusion of substance and style can garner a high price tag out in the marketplace. In fact, we found full tang, stainless steel blades with bone handles in excess of $2,000. Well, that won't cut it around here. We have mastered the hunt for the best deal, and in turn pass the spoils on to our customers.

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DUE TO THE MOVEMENT OF IRON AND nickel in our planet's outer core, Earth is continuously creating a magnetic field that forms the magnetosphere—a protective bubble that shields life from the radiative dangers of space. This sphere contains what's called a charge polarity, where the "morning side" is positively charged and the "evening side" is negatively charged. This creates an electric field that can have a profound effect on geomagnetic disturbances like solar storms.

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However, the traditional view of this charge polarity turns out to be more complicated than we thought. According to new satellite observations, the reverse of this view is actually true—at least around the equator. In a new study, a team of scientists discovered that in that region, the morning side of the magnetosphere is negative and the evening side is positive. Near the poles, however, the magnetosphere adheres to scientists' original charge-polarity view.

To look at this discrepancy more closely, the scientists used large-scale magnetohydrodynamic (MHD) simulations to recreate near-Earth space, simulated a stream of solar wind, and found that the simulation matched up with this new satellite data.

"In conventional theory, the charge polarity in the equatorial plane and above the polar regions should be the same. Why, then, do we see opposite polarities between these regions?" Yusuke Ebihara from Kyoto University said in a press statement. "This can actually be explained by the motion of plasma."

To understand the role of plasma, you'll need to know about Earth's magnetic field lines. These invisible lines travel in continuous loops and are nearly vertical at the planet's magnetic poles. When the sun's magnetic energy (or plasma) enters the magnetosphere, it moves clockwise on the dusk side of the planet, channeling toward the poles. However, the field lines run in opposite orientations, and it's these opposing forces that create the different polarities in different regions of the magnetosphere.

Not only does this discovery provide valuable insight into near-Earth space conditions, it gives us clues about the magnetic conditions surrounding other planets, such as Jupiter and Saturn. It also shows that there's still much more to learn about the dynamic magnetic conditions that surround Earth. *—Darren Orf*

ANCIENT JEWELRY

RING / Archaeologist Linda Åsheim—who discovered a medieval gold ring while digging less than three inches beneath the surface of Tønsberg, Norway's oldest town—told the Norwegian Institute for Cultural Heritage Research that she had quite the reaction: *Shit, is that gold?*

Experts firmly believe that the ring dates back to sometime between the ninth and 11th centuries and could have symbolized divine power and the ability to heal. Of course, it also may have simply been an expression of status.*—Tim Newcomb*

SCARAB AMULET / Archaeologists excavating near ruins on the island of Sardinia discovered an Iron Age scarab amulet from ancient Phoenicia. The distance this amulet traveled—over 1,000 miles—shows how the ancient island people were intricately involved in cross-cultural trade. Scarab amulets were prized both for the belief that they provided personal protection and for their practical use as seals.*—T.N.*



THE NORWEGIAN INSTITUTE FOR CULTURAL HERITAGE RESEARCH (NIKU) (RING); COURTESY ISRAEL ANTIQUITIES AUTHORITY (SCARAB)



Unsinkable Material

THE NATURAL WORLD IS HUMANITY'S greatest inspiration, and its influence can be seen all throughout our modern society. So it comes as no surprise that in the pursuit of creating an unsinkable ship, scientists have once again ripped a page from nature's playbook.

This time, the inspiration was drawn from one of the most fascinating arachnids in the animal kingdom: the diving bell spider (*Argyroneta aquatica*), the only species of spider to live almost entirely underwater. It still does have to breathe air, so it creates a dome-shaped web known as a "diving bell" and, using its superhydrophobic arms and abdomen, fills that web with air bubbles carried in from elsewhere.

For more than a decade, physicist Chunlei Guo has investigated ways to leverage the superhydrophobic abilities of the diving bell spider to create a material that's essentially unsinkable. In a new paper, Guo and his team have described what they call their most advanced prototype yet, simplifying and improving the technology in multiple ways.

In 2019, the team outlined a technique that etched complicated nano- and microscale patterns into metal so that they trapped air and created superhydrophobic surfaces. Two treated parallel plates were then arranged facing inward, trapping enough air to maintain flotation while creating a waterproof compartment. After submerging this material under load for two months, the structure immediately resurfaced when the load was removed.

While this design proved promising, it wasn't perfect, as the structures lost buoyancy when turned at extreme angles.

"[For the updated 2026 design], we added a divider to the middle of the tube so that even if you push it vertically into the water, the bubble of air remains trapped inside and the tube retains its floating ability," Guo said in a press statement. "We tested them in some really rough environments for weeks at a time and found no degradation to their buoyancy. You can poke big holes in them, and...they still float."

Guo said that these superhydrophobic tubes can be rafted together to handle large loads or serve as the flotation bedrock of emerging green energy technologies like wave energy generators.

Seems like we have a lot to thank a small, water-dwelling spider for.—*D.O.*

COURTESY J. ADAM FENSTER/UNIVERSITY OF ROCHESTER (METAL SAMPLE)

Treasure in the Great Wall



CHINA'S FAMED GREAT WALL continues to reveal secrets of the past. The latest glimpse into that rich history centers on a cannon from the Ming Dynasty, which shows the military focus of the Great Wall and offers insight into how ancient Chinese and European people traded military know-how.

Archaeologists excavated three watchtowers and connecting walls from the Jiankou section near Beijing. The most distinct find, according to Shang Heng, associate research fellow at the Beijing Institute of Archaeology, was a Ming Dynasty–era cannon.

The 35-inch, 247-pound cannon features the inscription "Chongzhen Year 5"—what we would now call 1632 C.E. The weapon has similarities to European-style red-coat cannons (including the size of the barrel) and fits within the battery platforms found on the wall, showing that a weapon of its style and size was likely standard atop watchtowers.

Heng said, "This provides crucial physical proof of Chinese–Western military technology exchange," according to the *Global Times*.

Beyond the cannon, crews also uncovered the contents of storage rooms used by troops, including a heated brick bed and stove in Watchtower 118. Watchtower 117 contained an immigration monument dated to 1573 C.E.

Three different bricks offered up additional information. Two included inscriptions noting weight specifications, upending previous beliefs regarding Ming-era brick kiln operations. Investigations into the lime mortar showed a high-magnesium lime mixture with plant fibers to help with adhesion.

The third brick's inscription translated to "nothing but alcohol or worry; three years of toil turned my hair white," and was likely inscribed by a wall builder.

"These findings transform the Great Wall from a cold military structure into a living historical landscape integrating defense, cultural exchange, and daily life," Heng said.

Researchers also discovered plenty of crops and medicinal plants, indicative of everything from diets to medical know-how. Investigation into animal bones highlighted both domesticated and wild animals at the site, including evidence of animal butchering.

Additionally, according to the *People's Daily*, crews found 28 turquoise artifacts. Deeper investigation suggests they came from the provinces of Hubei, Henan, and Shaanxi.

"The Great Wall's landscape and geography have barely changed [over time]," Heng said, "making it ideal for time travel–style restoration research."—*T.N.*

GETTY IMAGES (GREAT WALL)

Rapid Evolution

THE FAMOUS ANALOGY GOES THAT IF all of Earth's geologic history were compressed into a single calendar year, modern humans wouldn't make an appearance until around 11:50 p.m. on New Year's Eve. Considering our planet's immense past, it's remarkable how much our species has learned with those last few minutes before midnight.

However, there is still much more to learn. And while we've developed a reliable model to explain how life went from single-celled organisms to the complex web we see today, questions remain. Chief among them is the apparent fossil gap between when scientists believe complex life emerged and when we see the very first fossils.

Using the idea of the molecular clock—which, at its most basic, is working on the assumption that genetic changes occur steadily—scientists estimate that there is a roughly 30-million-year gap that's currently unexplained by what we see in fossils. Of course, fossils are difficult to find in the first place, and one theory is that these first animals were simply incredibly small and hard to find. But a new study takes issue with the molecular clock itself and suggests that evolution doesn't "tick" as steadily as we expect.



GETTY IMAGES (EVOLUTION)

Paleontologist Graham Budd and mathematical ecologist Richard Mann—both of whom have long analyzed the molecular clock—present an idea called the Covariant Evolutionary Tempo model to help explain some of the inconsistencies between the molecular clock and the fossil record.

"This model predicts that diversity is dominated by a small number of extremely large clades at any historical epoch including the present; that these large clades are expected to be characterized by explosive early radiations accompanied by elevated rates of molecular evolution; and that extant organisms are likely to have evolved from species with unusually fast evolutionary rates," the authors wrote.

In an article for *The Conversation*, evolutionary biologist Max Telford explains how this variable tempo could dramatically decrease the gap in time we expect between the emergence of complex life and the first observable fossils. Humans and chimps, for example, are separated by six million years of evolution. If there are six genetic changes between these two species, and the molecular clock is constant, this suggests one genetic change per million years.

However, the Covariant Evolutionary Tempo model suggests that when a big group of organisms appears, evolution speeds up. Those six genetic changes would occur over less time, making it appear like more time was passing when evolution was really on fast-forward.

"While the speeding clock idea needs testing," Telford wrote, "it could explain other mismatches between molecular clocks and the fossil record."—*D.O.*



Mythic Golden Armor

THE ANCIENT CHINESE LEGEND THAT Tang dynasty rulers donned gold-plated armor in battle has long been mere myth—until now. Researchers not only discovered a suit of gilded armor in a Tibetan plateau tomb, they've now restored the find.

In 2018, archaeologists first discovered the roughly 1,200-year-old suit of armor in what would eventually be confirmed to be the tomb of a Tuyuhun king, according to the Chinese Academy of Social Sciences (CASS). But, at the time, they didn't quite know what they had discovered. The fragments of armor were first believed to be bronze armor plates, many of which were rectangular with a semicircular lower edge. The fragments were often fragile, and many pieces were missing due to looting.

The team spent years working on the find, sifting through missing and damaged areas of the armor. "We adopted a strategy of disassembling the whole into parts and reassembling the parts into a whole, conducting layered cleaning, extraction, and protection," Guo Zhengchen, a conservationist working on the armor, said during a press conference, according to the *South China Morning Post*.

Eventually, the team realized that what they were working on was actually made of a golden bronze, bringing a Tang dynasty legend into reality.

The project embraced modern technology to bring new life to the legendary armor, including 3D scanning, microscopy technology, and both virtual and augmented reality used to help process the reconstruction. "These technologies have provided solutions to the challenges of artifact degradation, allowing for more accurate restoration, interactive displays, and global accessibility to cultural heritage," a group of archaeologists wrote about the process, according to CASS.

CASS stated that the "approach enabled the scientific restoration of several sets of precious cultural relics that were severely damaged and structurally complex," including the only physical example of Tang dynasty golden armor.

As evidenced by the unique armor, the Tuyuhun king seems to have enjoyed a little panache: In addition to his own metallic covering, he had quite a fanciful covering for his horse. The team found damaged lacquered horse armor, this one with gold adorning the edges, and restored it as well. Additionally, a lacquered tray designed to hold grapes was found in the tomb and featured intricate Tang dynasty gold-and-silver inlay. All of these finds help breathe new life into parts of Chinese history once thought to be only the stuff of legend.—*T.N.*

GETTY IMAGES (ARMOR)

The Father of Architecture

AN ANCIENT BASILICA DISCOVERED beneath the Italian city of Fano has been labeled "a sensational finding" by Italian Culture Minister Alessandro Giuli, "something that our grandchildren will be talking about."

After all, it was designed by the man hailed as the "father of architecture."

In the ninth book of his *De Architectura* treatise, Marcus Vitruvius Pollio laments the manner in which the Roman people seem to take their innovators for granted.

Vitruvius, as his name is often shortened, argues that the honors often imparted to athletes should be bestowed on writers, "for the wrestler, by training, merely hardens his own body for the conflict; a writer, however, not only cultivates his own mind, but affords every one else the same opportunity, by laying down precepts for acquiring knowledge, and exciting the talents of his reader."

The author may not have been compensated in the manner he suggested, but fame certainly gave Vitruvius's name an immortality. His writings inspired an array of Renaissance thinkers. In particular, Vitruvius's observation that the ideal human body "with his hands and feet extended, and a pair of compasses centered at his navel, the fingers and toes of his two hands and feet will touch the circumference of a circle described therefrom," was the inspiration for one of Leonardo da Vinci's most famous drawings, *Vitruvian Man*.

For millennia, the work of Vitruvius survived only in his written word, including his description of the only structure for which he claimed credit: a basilica built in Fano, Italy. Now, as of earlier this year, archaeologists believe they have found that basilica.

"I feel like this is the discovery of the century, because scientists and researchers have been searching for this basilica for over 500 years," remarked Luca Serfilippi, the mayor of Fano, per *Reuters*.

In the fifth book of *De Architectura*, Vitruvius provided a thorough description of the basilica "which I erected, and the building of which I superintended at Fano." Vitruvius wrote the description as a way to illustrate how basilicas "of the greatest dignity and beauty" could be constructed, but he had also inadvertently provided a map for archaeologists attempting to navigate the underground geography of the newly uncovered structure.

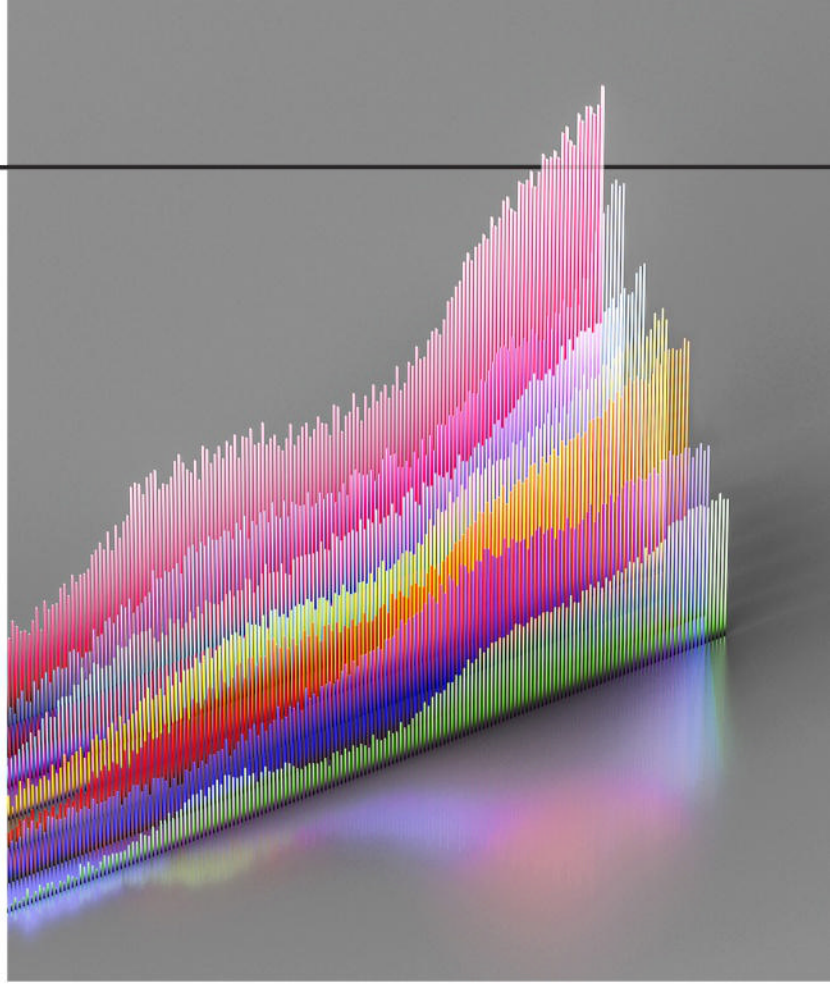
"During excavation," *Reuters* reported, "when traces of four columns emerged, archaeologists used Vitruvius's descriptions to calculate where the top right corner column should be." What they ultimately uncovered matched Vitruvius's description precisely.

All that's left now is to keep digging in order to see both how much of the structure is still underground and whether it's suitable to be viewed by the public in its current condition.—*Michael Natale*



GETTY IMAGES (BASILICA OF VITRUVIUS)

Predicting the Future



A TEAM OF MATHEMATICIANS has recently taken steps to improve our ability to predict future data. It's not exactly fortune-telling, but forecasting is a huge industry that much of our economy relies on—from making sure your favorite author's new book is in stock to ensuring there are enough turkeys for Thanksgiving this year.

Taeho Kim from Lehigh University led a team of seven mathematicians in this work, which is currently available as a preprint on *arXiv*. In the introduction, Kim and his team explain why prediction has turned from science fiction into essential global work:

"[P]rediction [functions are]...one of the most important and consequential endeavors of statisticians, mathematicians, machine learners, data scientists, and artificial intelligence researchers, with deep implications and utilities in many facets of science, engineering, medicine, health, economics, business, politics, and in general, society... Regression models, many machine learning algorithms, artificial neural nets, deep learners, and large language models are about prediction machines!"

Some people believe that with enough information, we could predict everything. Even if that's true, "enough information" is doing an enormous amount of work in that statement—researchers want to use prediction algorithms for datasets that are just too large to crunch. Most prediction work done on these complex problems is focused on a very small, specific area in which incomplete information can be completed with reasonable guesses.

This work has long centered on two predictors. The Pearson's (or classical) correlation coefficient (PCC) measures how much two variables—say, hotel cost and quality of breakfast—agree with each other along a line. The concordance correlation coefficient (CCC), on the other hand, "requires that Y and X possess the same units [and]...that Y and X be measurements of the same characteristic, trait, or phenomenon," the paper explains. By using more specific requirements, the CCC is able to measure not only the closeness of two variables to a prediction but also how meaningful the amount or degree of agreement between them is (based on shared units or scope).

The team suggested a new predictor: the maximum agreement linear predictor (MALP). Without getting lost in the weeds, the MALP is a fine-tuning of the CCC that may better measure the very specific relationships that the CCC itself already excels in measuring. What results, the team concludes, is a MALP prediction with higher overall agreement. It also might open up the oppor-

GETTY IMAGES (GRAPH)

tunity to analyze data that is less organized around traditional XY plots—something that linear regression has always struggled to represent.

The researchers conclude their work with a list of next steps, including questions that must be asked in further research into the MALP. For a visceral sense of how important this work can be, think of the story in *Jurassic Park*. What if we have 95 percent of an animal's genome and use a predictive algorithm to sketch in the remaining 5 percent? The results won't be fictional monsters, but they also may not be living beings. Our ability to fill in missing information can have truly massive impacts on the conclusions we are able to draw from datasets.

One huge area affected by prediction algorithms is the field of measurement itself. "[R]eproducibility, assay validation, and other types of agreement studies" are all sub-areas of potential application highlighted by the team. In the sciences, reproducibility is obviously a hot topic, but agreement studies are also critical—specifically for meta-analyses where slightly different studies of the same phenomenon are combined in order to draw broader conclusions.

> *"WHAT IF WE HAVE 95 PERCENT OF AN ANIMAL'S GENOME AND USE A PREDICTIVE ALGORITHM TO SKETCH IN THE REMAINING 5 PERCENT? THE RESULTS WON'T BE FICTIONAL MONSTERS, BUT THEY MAY ALSO NOT BE LIVING BEINGS.*

In a statement, Taeho Kim said that while this paper focuses on the 45-degree line of agreement between variables, he hopes the MALP can become the maximum agreement predictor more generally. "We need to investigate further," he concluded. *—Caroline Delbert*



GETTY IMAGES (POMEGRANATE)

AGING CELLS

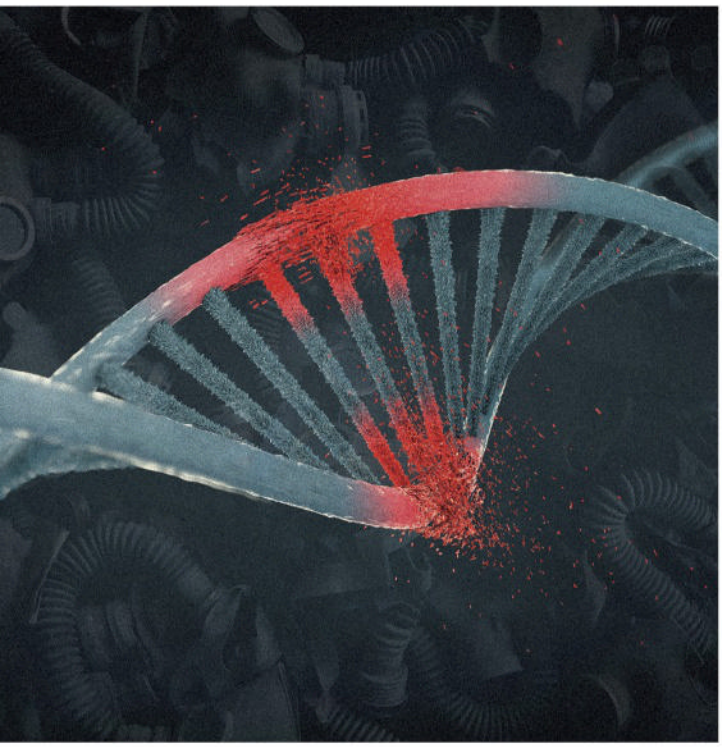
DE-AGED IMMUNE SYSTEMS / Foods such as pomegranates, walnuts, and certain types of berries contain polyphenols that can help reverse the effects of immune system breakdown from cell aging. These compounds are metabolized by bacteria in the gut and release urolithin A, which energizes tired cells and boosts aging immune systems. Because this polyphenol reverses processes that lead to cell dysfunction and death, it may be powerful enough to prevent cancer.*—Elizabeth Rayne*

RECHARGING CELLS / Many degenerative diseases are partially caused by mitochondrial dysfunction in cells. Researchers have learned to implant biomaterial structures within donor stem cells to help them produce more mitochondria. When these cells were placed with damaged cells, mitochondria transferred and rejuvenated the recipient cells, which has promise for future treatments.*—E.R.*

The Stewards of Chernobyl

ABOUT AN HOUR AND A HALF PAST midnight on April 26, 1986, an unexpected power surge coursed through a reactor at Ukraine's Chernobyl power plant. The now-famous explosion that ensued unleashed ionizing radiation.

Deaths from radiation poisoning were only the beginning. Hundreds of thousands of workers were involved in the cleanup of contamination, but many of them had no idea that the explosion would warp their genes—and those of their offspring. Now, an international team of researchers led by physician and geneticist Peter Krawitz from the University of Bonn in Germany has revealed how the effects of ionizing radiation can be passed down to the children of those exposed.



Intense energy from radiation has detrimental genetic effects. Ionizing radiation, as the name suggests, ionizes water molecules in the cell to create unstable and highly reactive forms of oxygen. This can break strands of DNA or cause lesions to DNA bases through oxidative damage, both of which can lead to cell death and instability in the genome. Mutations can also occur through translocations, which is when chromosomes break and those fragments attach to other chromosomes.

And the problems, Krawitz and his team thought, might not stop there. To see whether DNA lesions caused by ionizing radiation could be detected in the children of those directly exposed, Krawitz sequenced the genomes of Chernobyl cleanup workers and retired Cold War–era German military radar operators.

Searching for mutations, the research team looked for locations in DNA with multiple lesions. And there were, predictably, more mutations in the offspring of fathers who had been exposed to radiation than there were in the control group. Though not many mutations were severe, the increase in new mutations *was* correlated with paternal radiation exposure, meaning these mutations can be transgenerational.

However, it is highly unlikely that the offspring of parents who had been exposed to radiation will develop genetic diseases from their mutations. Krawitz found that, despite lesions being carried between generations, the risk of genetic diseases due to parental age at the time of conception is actually higher than the risk carried by mutations.

"The present study is the first to provide evidence for the existence of a transgenerational effect of prolonged paternal exposure to low-dose [ionizing radiation]," Krawitz said. "The present findings suggest several further promising research avenues for characterizing further transgenerational signatures of the effect of [radiation] on the human genome."—*E.R.*

ILLUSTRATION BY ELENI ARPINO USING GETTY IMAGES (CHERNOBYL DNA)



The Great Green Wall

IT'S NO SECRET THAT CHINA IS particularly adept at building things. The world's largest dam? In China. Largest high-speed rail network? That'd be China. Largest ancient landmark? You get the picture.

Alongside all of that building, China has been growing the Three-North Shelterbelt, or "The Great Green Wall," since 1978 to combat soil erosion and decrease desert storms. The project, the country's state-sponsored media announced, was finally completed last year.

According to *Reuters*, China grew 116,000 square miles of trees, increasing the country's total forest coverage from 10 percent in 1949 to roughly 25 percent in 2024. But a new study shows that all those additional trees (roughly 78 billion since the early '80s, by some estimates) come with some unforeseen consequences for China's water distribution.

A team of scientists found that between 2001 and 2020, increased vegetation reduced water resources in both the eastern monsoon region and the northwestern arid region. That's a big deal, considering these areas make up roughly 74 percent of China's total land area, according to *Live Science*.

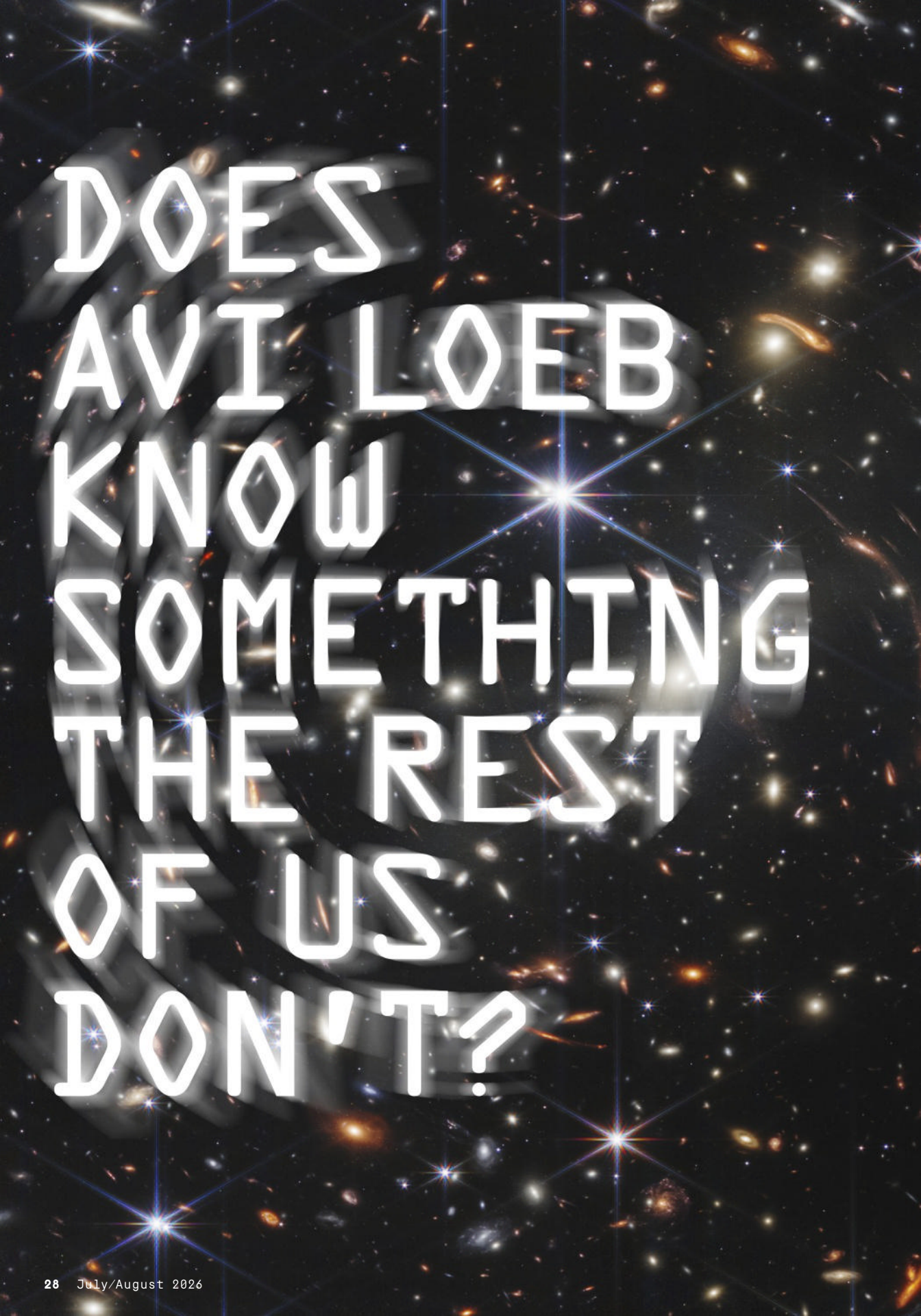
According to the study, regreening efforts like the Great Green Wall have increased evapotranspiration, which is a portmanteau of evaporation and transpiration (the process by which plants release water vapor through tiny pores known as stomata).

"These shifts caused changes in precipitation, directing more moisture to the Tibetan Plateau, which saw an increase in water availability," the authors wrote. "In contrast, eastern and northwestern China experienced a decrease in water availability, with the northwest losing the most due to substantial moisture moving to the Tibetan Plateau."

By studying these rapid land use/cover changes (LUCC), the authors also note that certain zone transitions—such as grasslands-to-forests or croplands-to-grasslands—impacted evapotranspiration, precipitation, and water availability at varying rates. For example, grasslands that transformed into forests increased evapotranspiration and precipitation but negatively impacted water availability.

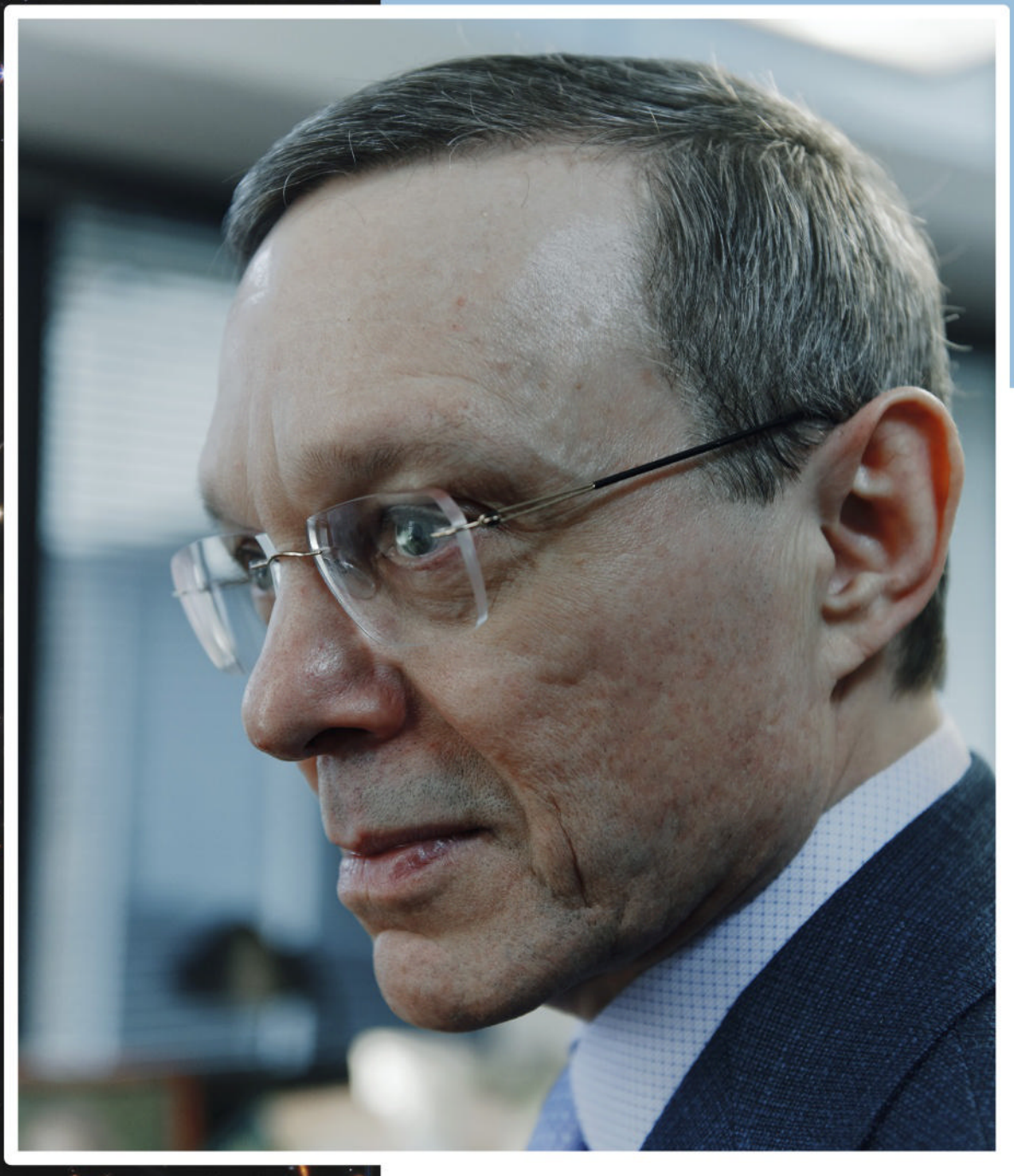
Unfortunately, China's water availability isn't conveniently distributed for its population. According to the study, the country's northern regions contain roughly 46 percent of its population and more than half of the arable land—but only 20 percent of water availability. The authors argue that these altered hydrological cycles need to be taken into account when planning future reforestation efforts.—*D.O.*

GETTY IMAGES (GREEN DUNES)


DOES
AVI LOEB
KNOW
SOMETHING
THE REST
OF US
DON'T?

BY DAVID HOWARD ✦ PHOTOGRAPHY BY TONY LUONG







The Harvard astrophysicist has devoted years—and thousands of interviews—to the idea that mysterious objects streaking through space could be alien technology. **What if he's right?**



AVI LOEB IS ANTSY.

HE IS SITTING IN HIS OFFICE AT THE HARVARD & Smithsonian Center for Astrophysics, waiting to be interviewed on a midday Newsmax program. He did not prepare for the Q&A; there are no notes to keep him on message. He doesn't check the vast whiteboard speckled with formulas across the room or even a mirror to assess his short, neatly combed, brown-but-graying hair. Moments earlier, he simply shrugged on his navy suit jacket over a lavender button-down and pointed me toward the ancient burnt-orange sofa next to his desk. Then he sits, streams the show on his computer, and waits.

Five minutes pass, then 10, as the hosts riff on welfare fraud and other conservative *causes célèbres*—what Loeb thinks of, in his post-partisan way, as terrestrial matters. As it becomes clear he'll be running late to the weekly luncheon of the Institute for Theory and Computation, which he leads, he shifts in his seat, begins to fidget. The producer pops on to assure him they're almost ready to go.

"Okay," Loeb replies, with a serrated edge of testiness, "but in five minutes, I'll have 100 people waiting for me."

Most academics would reshuffle their week for the chance to shill their research on a national news show. But Loeb has been doing interviews all week—an average of eight per day, he says—because of his take on 3I/ATLAS, an interstellar object that has captured public fascination. (The "3I" indicates that it's the third known interstellar object to pass through our celestial backyard; ATLAS is an acronym for "Asteroid Terrestrial-impact Last Alert System," the Chile-based telescope network that first detected it.) The astronomy community generally agrees it's a comet—potentially the oldest one ever seen. But Loeb, while conceding this is likely true, has repeatedly pointed to what he contends are unexplained anomalies that raise the possibility of a projectile sent by an intelligent life form from elsewhere in the universe.

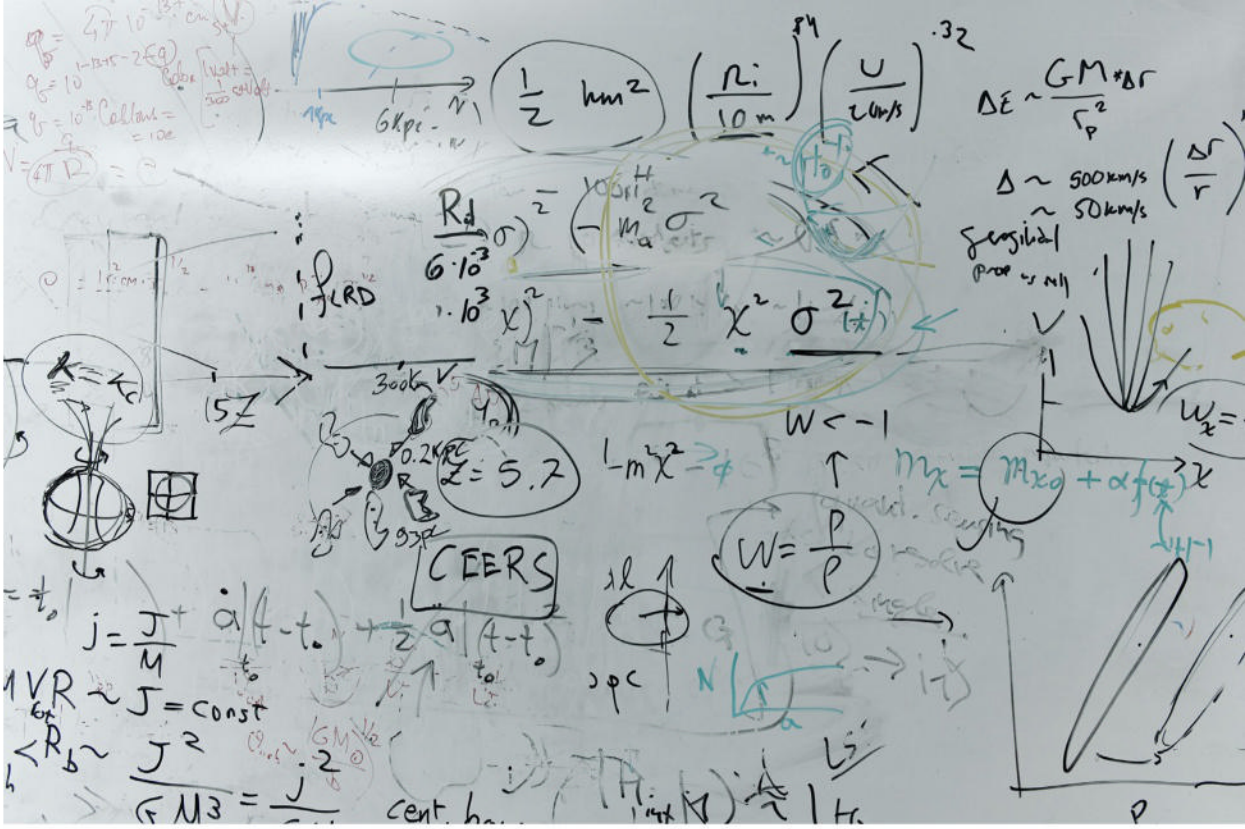
Over the past eight years, Loeb has gained worldwide notoriety for advancing such provocative notions, propelling him ever deeper into the pop-culture zeitgeist. Three weeks earlier, he'd flown to a NASCAR event in California in which a race car, emblazoned with Loeb's face, was dedicated to the interstellar object. In 2025, he landed on the front page of *The New York Times* as part of a story about NASA and Kim Kardashian's fascination with 3I/ATLAS. A recent Loeb appearance on *The Joe Rogan Experience* racked up a combined audience of 6.4 million on Spotify and YouTube.

When the interview finally begins, the host, eager for a spicy take, plays a clip from then-acting NASA Administrator Sean Duffy saying that scientists have concluded that 3I/ATLAS is definitely a comet. "How do you respond to that, Dr. Loeb?"

He is coiled to unload. "Oh, very simply, the foundation of science is the humility to learn, not the arrogance of expertise," he says. "It doesn't make sense to say, 'The experts say,' and therefore you should believe it. It makes sense to say, 'Here is the evidence, and it's a comet beyond a reasonable doubt because of this and that piece of evidence.' However, there are all these anomalies about this object, and we still haven't figured out what it is."

In July 2025, when 3I/ATLAS was first spotted more than 400 million miles from the sun, the object was already enveloped in a cloud of dust and gas, which makes it distinct from the typical dark and inert state of most comets at that distance. Its trajectory also has varied from that of an object pulled by the sun's gravity alone, and it possesses much more carbon dioxide than most solar system comets, as well as high levels of nickel. And as 3I/ATLAS made its closest approach to the sun

GETTY IMAGES (GALAXY)



in October, it brightened and shifted hues, adding blue-green colors. Loeb concludes the six-minute segment by inveighing against the likes of Duffy, who he says pose a danger to science. Then he smiles, thanks the host, and bounds up from his desk. "Let's go," he says. "The people are waiting."

And he's off, racewalking down the labyrinthine halls of the esteemed Harvard edifice. I briefly pause to organize myself, which is a mistake; he vanishes so quickly I end up having to ask for directions. It's fitting: Loeb is careening forward with his unusual career pivot at such a furious pace that it's impossible for anyone—even him—to know where this will all end up.

TWO BRONZE BUSTS OF GALILEO WERE AMONG the first things I'd noticed upon entering Loeb's office for the first time. It's tempting to infer in this placement an unsubtle attempt to entwine his narrative with that of the iconic trailblazer. Galileo was famously jailed for his unorthodox and heretical ideas—and, of course, was ultimately vindicated. Appearances aside, Loeb insists there is no such messaging at work: The acclaimed artist Greg Wyatt recently gifted him the art, which will be officially conveyed in a ceremony the next day.

Loeb is a diminutive, even elfin, 64 years old, and he wears round, rimless glasses. He jogs three miles each morning and adheres to a version of the keto diet that accommodates the daily consumption of three whole bars of dark chocolate, which doubles as his source of caffeine since he avoids coffee. Loeb says these changes caused him to shed about a third of his body weight and sharpened his mental acuity. His jacket envelops his slender physique like a tarp.

▲ Avi Loeb's whiteboard in his office at the Harvard & Smithsonian Center for Astrophysics on May 7, 2026.

He was born on a farm near Tel Aviv; the family grew pecans, oranges, and grapefruits. He was an intense reader, a restless thinker. "I would drive a tractor to the hills of the village and read philosophy books on the weekends," Loeb says. His German-Jew grandfather, Albert, fought for Germany in World War I; in the 1930s, a Nazi criticized the local Jews at a public meeting. The story goes that Albert stood up and boomed, "How dare you say that? I served in the military in the First World War, and you dodged the draft because you were a communist at the time."

"We all know about you, Mr. Loeb, and appreciate you," the young Nazi replied. "I'm talking about the other Jews."

Loeb relates this story to his present circum-



stances, in which he is personally targeted by critics eager to refute his claims. "It tells you that when you don't know someone, you can easily hate them and go crazy—kill them...but once you find that they have a family, it's much more difficult," he says. "And so for these zealots to attack me, obviously a prerequisite is for them not to know me."

Soon after the town meeting, Albert Loeb joined over 60,000 German Jews who fled to Palestine, and Avi's mother, Sara, was born in Bulgaria and survived the Holocaust before immigrating to Israel in 1948. But 65 of Loeb's family members perished in the Holocaust, and this history of persecution looms conspicuously in his present-day narrative.

While serving his obligatory Israeli military duty at 19, Loeb entered Talpiot, an elite unit that today accepts only about 50 recruits annually for defense-related intellectual work. This allowed him to finish his doctorate at the Hebrew University of Jerusalem at age 24, studying the plasma acceleration of charged particles. He and a collaborator later proposed what became the first international project in Ronald Reagan's "Star Wars" program, developing a new propulsion method for high-speed projectiles. This work—military, applied, focused on exotic forms of propulsion—informed his later fascination with alien spacecraft.

After a fellowship at Princeton, he landed at Harvard in 1993 as an assistant professor of astronomy and was tenured just three years later—an astonishingly fast ascent. Many prominent titles soon followed: the longest-serving chair of the university's astronomy department, director of the Institute for Theory and Computation, and founding director of Harvard's Black Hole Initiative, the world's only center dedicated solely to the study of that celestial phenomenon. He has authored or coauthored more than 1,000 papers, the topics ranging from the first stars and galaxies to black holes and beyond. He could have remained perched atop this prestigious, if relatively anonymous, corner of academia. But in October 2017, a strange object came streaking across the sky.

OUMUAMUA WAS THE FIRST KNOWN INTER-stellar object to pass through our solar system. Discovered by a Hawaiian telescope, it appeared to be a cigar-shaped form with no tail or coma, the fuzzy cloud of gas surrounding active comets, and it exhibited a slight but measurable acceleration away from the sun that couldn't be written off to gravity alone.

▶ Avi Loeb has two bronze Galileo sculptures, plus 51 framed watercolor portraits of famous scientists, decorating his office.

Most planetary scientists offered mundane explanations: exotic nitrogen ice, a hydrogen iceberg, or cometary outgassing from a surface not visible to telescopes. But in October 2018, Loeb and a postdoc submitted a paper to the *Astrophysical Journal Letters* proposing that Oumuamua could be alien technology employing a "light sail" to propel itself using solar radiation. Picture a spacecraft using a large, thin reflective surface to harness photons, or light particles, the way a schooner catches wind.

But never had someone possessing his scientific cachet been so willing to speculate on the tangible possibilities of alien life in such a public way. "Within a week," he says, "I had television crews showing up at my front door."

Squinting into the glare of such intense notoriety for the first time, some might have quickly turtled up. Loeb instead navigated directly into the eye of the storm, embracing the klieg lights and the role of academic provocateur. In January 2021, he published *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth*, which expanded his Oumuamua argument into a popular science narrative. The book debuted at No. 7 on the *New York Times* bestseller list and was translated into 25 languages. His fame, and the private money that followed, have allowed Loeb to disengage from a near-umbilical dependence on NASA and other conventional funding sources for research.

During the first day of my visit, Loeb leads a Zoom with other principals in the Galileo Project, an organization created to identify the many unexplained objects circling our planet's skies. "The Pentagon is unable to tell us what some objects in the sky are, so they're not doing their job," he tells me. "That's a serious matter." So far, the organization has installed telescopes in Massachusetts, Pennsylvania, and Nevada, each of which cost $1 million to $2 million, to capture celestial data. The project's money flowed in from foundations or citizens who heard about Loeb's research. The Black Hole Initiative has similarly run on donations for its entire nine-year existence.

But the highest-profile use of private money went to his most far-flung research effort. In 2019, Loeb and an undergraduate research assis-



tant identified a meteor in NASA's Center for Near-Earth Object Studies (CNEOS) catalog that appeared to have entered Earth's atmosphere at a speed exceeding that of objects originating from within our solar system. The fireball exploded over the Pacific Ocean near Papua New Guinea in 2014. NASA declared it an interstellar object with 99.999 percent certainty, and Loeb's team named it IM1, for Interstellar Meteor 1.

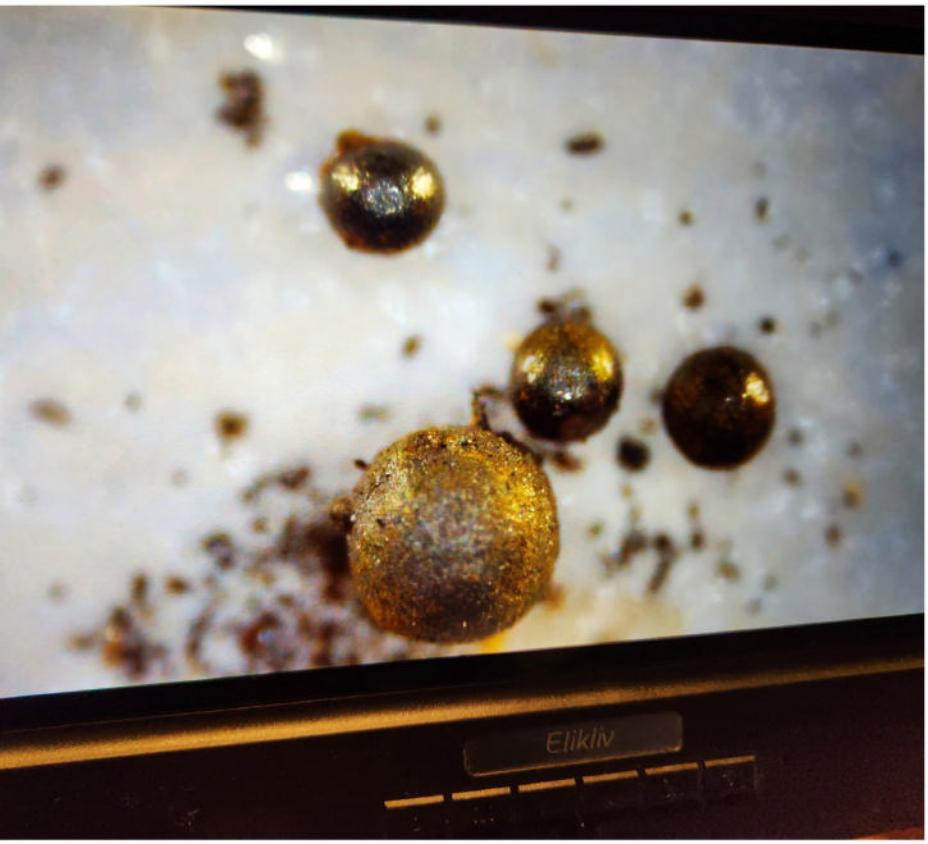
In 2023, using a $1.5 million donation from Charles Hoskinson, cofounder of the Cardano blockchain platform, Loeb led an ocean expedition in which researchers dragged a magnetic sled across the ocean floor in an area along the meteor's calculated path. They dredged up over 700 tiny metallic spherules that, upon analysis, contained an unprecedented combination of beryllium, lanthanum, and uranium in abundances that Loeb described as "tantalizingly different by factors of hundreds from solar system materials." He claimed that this pointed to an interstellar, possibly extraterrestrial technological, origin.

Left: Molten droplets from an interstellar meteor. Right: Avi Loeb on a ship in the Pacific, collecting fragments from the meteor.

THE WORLD ACCORDING TO AVI LOEB IS NEATLY bifurcated. On one side are the curious, eager to inspire an incoming generation of young scientists. On the other side are the bureaucrats obstructing the flow of information; the experts who robotically hew to conclusions that only fit datasets they've seen before; and the online haters like Neil deGrasse Tyson, who pop off on science without actively doing research, are envious of his fame and following, and are diagnostic of a larger societal syndrome—the failure to open the mind to possibility, to follow clues that might lead beyond the beaten path.

Then there is the "God of the gaps," a theological concept created in the 1800s. When early people encountered phenomena they couldn't explain, like thunder and eclipses, they often ascribed them to the work of a higher being. As science explained these events, the gap narrowed between mythical explanations and a fact-based understanding of what was actually occurring.

This is one of the criticisms of Loeb advanced by Mert Bayar, PhD, a researcher at the University





COURTESY AVI LOEB (MOLTEN DROPLETS)

of Washington's Center for an Informed Public who has studied the 3I/ATLAS conversation—that Loeb is driving an updated version of this concept. Thanks to Loeb, Murat argues in an article on the center's website, "Some of us now do with aliens what we once did with gods. When a 'mysterious' comet, signal, or anomaly shows up, some reach for intelligence to explain it. If astronomers haven't nailed down every parameter of an object's orbit, speed, composition, or brightness, the gap is quickly filled with talk of probes, motherships, and extraterrestrial technology."

Bayar contends that Loeb has created a reality distortion field around the Search for Extraterrestrial Intelligence (SETI) by vaporizing any distinctions between 3I/ATLAS and alien spacecraft to a guileless public—all while serving a self-appointed role as astronomer to the people. While Loeb has conceded that 3I/ATLAS is "most likely a natural interstellar comet," and said he would agree with whatever the evidence shows, he then "spends far more time walking through its supposed 'anomalies' and entertaining the alien-technology hypothesis," Bayar wrote. "For most audiences, the volume and emphasis of that speculation effectively buries the initial caveat."



COURTESY AVI LOEB (SILVER STARSHIP DECK)

Other researchers have attacked Loeb's science. After his IM1 expedition, one study showed that the seismic signal Loeb's team used to narrow their ocean search was almost certainly caused by a truck driving past a seismometer on Manus Island, not the meteor. Another scientist reported that the combination of elements in the spherules matched the known composition of coal fly ash—industrial waste from coal-burning power plants and steam engines. Yet another noted that the speeds IM1 was traveling would have rendered any surviving material aerosol-sized—far smaller than the recovered spherules. Loeb has rebutted each criticism vigorously, maintaining that the spherule composition is not coal ash and that satellite data from the Department of Defense primarily determined the expedition's search area.

Things have gotten personal. Commentators have created lengthy multipart YouTube videos with titles such as "Avi Loeb is a Fraud," the second installment of which runs at over 92 minutes. Some critics—such as the creator of a video titled "How an 'Alien Invasion' Makes $1.1 Billion for Avi Loeb"—accuse him of being a grifter out to profit from his claims. (Loeb says he uses all donated funds on research.)

Loeb acknowledges that criticism comes with the territory. But the result has largely been a kind of omnidirectional defensiveness, with Loeb—who doesn't participate in social media—firing indiscriminately from the wings of his Harvard parapet. He suggests much of it is jealousy. His tormentors are "mediocre scientists that have no way of getting to the limelight...unless they attack me."

But he has also attacked those who have contradicted his work, including many astronomers. I reached out to a handful, and most didn't reply. But Jason Wright, PhD, professor of astronomy and astrophysics at Penn State University and director of the university's Extraterrestrial Intelligence Center, did. He worked with Loeb in 2020 and 2021 on a NASA-funded research project focused on understanding technosignatures, or artificial gases in exoplanet atmospheres. On his personal website, Wright chronicled how Loeb has triggered anxieties about alien invasions and the end of the world.

Wright acknowledges that Loeb has created cover for legitimate scientists doing serious work in the SETI arena. But he is troubled that Loeb never acknowledges any errors, nor does

he explain the context behind certain ideas. "It should always be okay to say, 'I know this is out of favor, but it's still technically in play, and I want to flesh that out.' We have a very high tolerance for that," Wright says. "But when we communicate to the public, it's a completely different mode, because they don't have that shared context, and so you have to present it clearly if you want to fairly explain the state of play. And his readership gets a really distorted idea of what professionals in the field think is likely and true about comments in general and specific ones."

There is evidence the spillover from this ongoing feud impacts the people Loeb works with. During my visit, he held his weekly meeting with Devesh Nandal, a postdoc working on research involving the potential for life around massive stars using computational models to predict habitable zones and durations. Nandal, who holds a PhD in the evolution of massive and supermassive stars, says his previous postdoc managers took a flyover approach to his research. By contrast, Loeb "gives valuable feedback," Nandal says. "And at my level, I don't need hand-holding...but he definitely gives me good ideas." In an unusual move, Loeb has also paid $4,000 to $5,000 in fees to help Nandal publish his work in academic journals.

But Nandal says he has been warned within the academic community—at Harvard and elsewhere—not to closely associate himself with Loeb. "They've told me to only do one or two papers with him," Nandal says. "Don't do any work with him, because it is a real taboo...they think that the work he's doing is completely wrong or crazy."

Other students acknowledge Loeb's baggage but nonetheless find their time with him worthwhile. Sophie Bergstrom, an astrophysics student who worked with Loeb for two summers and took part in the Papua New Guinea expedition, says the extraterrestrial commentary on his work is overblown. "When you talk to him, it's very reasonable," she says. "It's like, okay, he's trying to search for extraterrestrial life and evidence of extraterrestrial life using the scientific method. That's what scientists do. But when you read anything in the news, it seems so much more exaggerated."

THE CRITICS NOTWITHSTANDING, LOEB continues to draw favorable attention from unexpected quarters. That's evident on my last afternoon at Harvard, when Greg Wyatt arrives to dedicate his Galileo sculptures and other artwork at a special event in the Wolbach Library.

As they prepare for the event in Loeb's office, Wyatt, wearing a fleece vest, red scarf, and beret, presents him with a third gift: a Citarella bag containing a humanoid with unnaturally long limbs made from some sort of pliable material. A coil of wire is looped over it, and there's a tub with more parts and tools attached to the top. "Oh wow—yeah, that's amazing," Loeb says, then he looks with bemused puzzlement at Wyatt. "What is it?"

"We want you to create a sculpture," Wyatt says. "You can change the pose. It doesn't have to be a figure; you can add to it, you can subtract, you can put celestial orbs."

"You know, my wife always tells me I need a hobby," Loeb replies.

"I have a suspicion you're America's next great sculptor," Wyatt says, and they laugh.

Loeb is pleased and baffled. "Okay," he says, his voice rising an octave. "That's a great challenge." Wyatt promises to bronze it after Loeb is done.

Watching his interactions, I'm struck that Loeb has the message discipline of a lifelong politician. He repeats certain phrases—"the arrogance of expertise"—in TV interviews, on podcasts, and in front of his Harvard audiences. Another expression involves Galileo: "Today he would have been canceled on social media," he says. "And that's why he's a hero of modern science."

Down in the library, Loeb observes that Wyatt's art elevates his workspace. "Whenever I enter my office, it doesn't feel lonely anymore," he quips. Loeb then uses that thought to pivot to the emptiness of space—or at least the version of space "you will find in the textbooks. But obviously, there is a sibling out there in our family of intelligent civilizations. He wouldn't feel that lonely if we have an emotional connection, and this is pretty much the sense we have when we create art, because we make the physical reality around us more connected."

He then delves into an update on 3I/ATLAS, complete with recent images projected onto a screen. After Wyatt's talk, the composer in residence, David Ibbett, performs a new musical piece that explores the intersection of art and science.

A reception follows, and the crowd eventually files out, leaving Loeb and me alone in his office. He seems to be feeling expansive. He says some-

one suggested he is only doing what he's doing to win the Nobel Prize, which he scoffs at. "If I discovered extraterrestrial intelligence, I would not waste time on wearing a tuxedo and going to Stockholm, because there will be more important things to attend to," he says. He jabs a thumb back at the Galileo bust looking over his shoulder. "But gladly, so far, they didn't put me in house arrest like this guy."

Sometimes when he thinks about his work, Loeb considers his parents—particularly his mother, a relentless thinker who published a book about Franz Kafka's Jewish identity; she loved to debate. Her passing, just a couple months after his Oumuamua paper landed, shaped Loeb's journey forward. "I don't think my mother would have approved of me going so much against the grain," he says. "She would have said, 'It's not good for you, people will attack you.'"

But her death "gave me this freedom of, 'Okay, I will not make her upset if I do that.'" He has no regrets. If he were to follow the conventional path, he says, "It's not clear that I would have left as much of an imprint on society, on academia. So that was my choice."



And his dramatic career pivot has the backing of his nuclear family, including his daughter Lotem, a junior at Harvard. "I think that has been an incredible development in his life," she says, "because previously, it might have been my elementary school class that he was lecturing to about black holes turning you into spaghetti. But now he has such a broader impact, and I think that makes him so much happier."

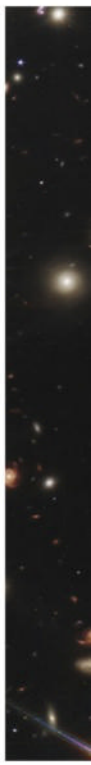
To the extent that it's possible to discern a motive in his ongoing quest, that seems as good as any: Loeb is doing this because it excites him, and it's perhaps a chance at a kind of immortality. He's the only male family member in his generation who has children. They're both daughters, so the family name may blink out when he's gone. He shrugs at this. "If you look at the cosmic scheme of things, it's not so important, right?"

Loeb can come across less a conventional academic than a highly credentialed performance artist who uses the language of science to challenge its most rigid conventions. But he's yet to convert his provocations—the philosophical musings he enjoyed so much as a boy—into data that proves anything exists beyond Earth. But then he trots out another talking point. When he was in the military, there was a saying: "Sometimes you have to put your body on the barbed wire to allow others to move forward, to cross over."

▲ Over 5 million people have read Loeb's essays on the content site Medium; he often writes after waking around 3:30 a.m.

I ask him if he has any ideas for his sculpture project. "I decided just now that instead of making a human out of this, which probably any sculptor more competent than me can do much better, I will make an alien out of this. But I have to think about what the alien will look like."

Whatever Loeb makes of his art project, this much seems clear: He'll see something in that mess of glue, rubber, and wire that the rest of us could never imagine.



BY
BRADLEY FORD

PHOTOGRAPHY BY
TREVOR RAAB



GOT A PIZZA OVEN? YOU NEED TO BUILD THIS DIY CART



Your pizza game might mirror mine. You've invested in a nice pizza oven, learned how to use it, and made pizza night a new tradition at home. But, have you struggled with where to put it—balancing prep area, table space, and a spot for the propane tank? I finally took the time to do something about it—and you can, too. I designed this pizza oven cart with flexibility in mind: There is room to store pizza dough boxes and other supplies, and you can adjust the dimensions to fit your oven and storage needs. Feel free to even swap out materials for the side panels to suit your personal style. ¶ You can build this pizza oven cart exactly as we have, but we love when you take our ideas and run with them—customizing, altering, or improving to make a great project even better. Have fun with it and build something that will make you proud.

GETTY IMAGES (ILLUSTRATION)



TOOLS

- ☐ Welder (arc, MIG, or TIG)
- ☐ Angle grinder
- ☐ Metal chop saw, band saw, or hacksaw
- ☐ Square
- ☐ Clamps
- ☐ Rivet nut tool
- ☐ Assorted screwdrivers and wrenches
- ☐ Miter or circular saw
- ☐ Drill
- ☐ Assorted drill bits
- ☐ ⅝, ¾, and 1-inch Forstner drill bits
- ☐ Jigsaw

MATERIALS AND SUPPLIES

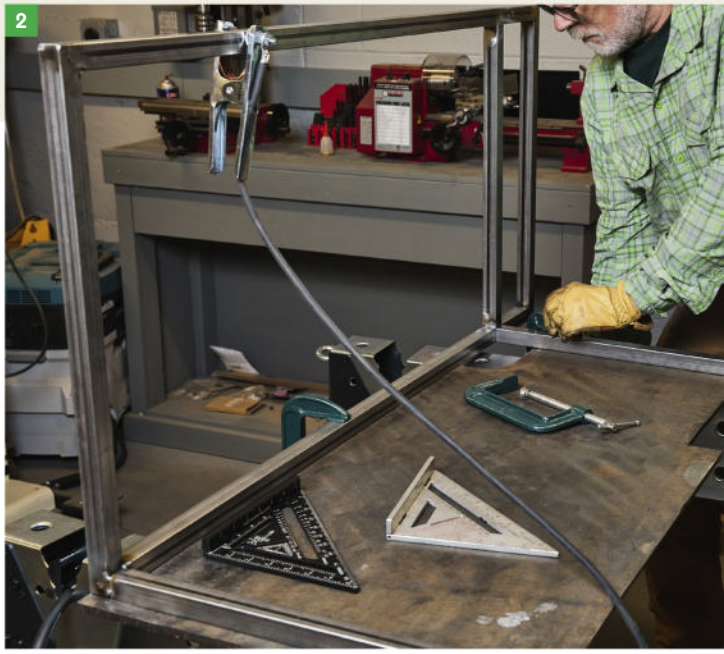
- ☐ 1" x 1" x 1/16" square steel tubing
  - 46" (x2)
  - 40" (x2)
  - 22" (x4)
  - 34" (x4)
  - 20" (x1)
- ☐ 1½" x 1½" x ⅛" angle iron
  - 18" (x6)
  - 36" (x2)
- ☐ 1" x 1" x ⅛" angle iron
  - 20" (x2)
- ☐ 1" x ⅛" steel flat bar stock
  - 6" (x8)
  - 20" (x2)
- ☐ Pallet slats—quantity depending on width, but enough to make:
  - two 37½" x 33½" panels
  - one 19½" x 33½" panel
- ☐ 24" x 42" stone countertop
- ☐ Silicone adhesive
- ☐ 17½" x 19¾" piece of ¾" plywood
- ☐ 17¾" x 19½" piece of ¼" plywood (x2)
- ☐ Set of 3" caster wheels (two swivel, two fixed)
- ☐ ⅝" round magnets (x4)
- ☐ M8-1.25 rivet nuts (x12)
- ☐ M8-1.25 x 20mm flanged hex head bolts (x12)
- ☐ #8 x ¾" truss head screws (x8)
- ☐ Sandpaper, assorted grits
- ☐ Etching primer spray paint
- ☐ Matte black spray paint
- ☐ Pizza dough proofing boxes (x2 or more)
- ☐ Optional: stain/paint

Build Notes // This pizza oven cart has a sturdy metal frame, so you'll need a welder. Any type will do, but a metal inert gas (MIG) or tungsten inert gas (TIG) welder will require less finishing. If you choose to make the side panels from pallets, you can usually find them free or very cheap on Facebook Marketplace. You could also use metal barn siding, T111 plywood, salvaged planks, picket fence panels, or lattice—use your imagination. For the top, we got a stone countertop remnant at a local dealer—they'll usually cut these to size and finish the edges for you. You could also make the top out of butcher block, but it may be hard to maintain if you store the cart outside.

Step 1 Build top and bottom frames // Cut the square steel tubing into the following lengths: 46 inches (x2), 40 inches (x2), 22 inches (x4), and 20 inches (x1). These will be used to make two rectangles, so the ends of each piece will need to be miter cut at 45 degrees. Lay the pieces out to make one 22 x 46-inch (top frame) and one 22 x 40-inch (bottom frame) rectangle. Tack the outside and inside corners. Check that each corner is square and that the frame is flat, then weld all sides of each joint.

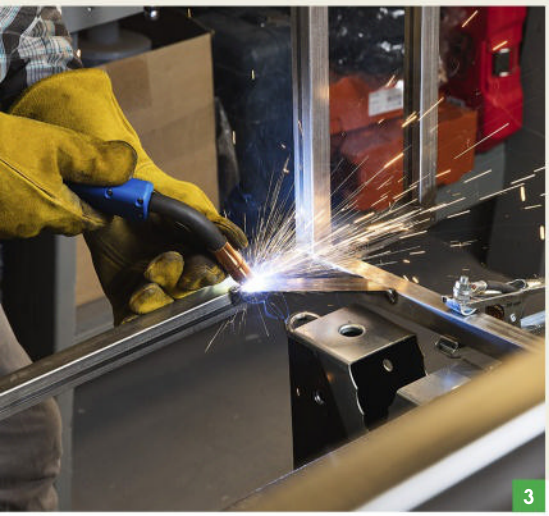
Lay the top frame (22 x 46 inches) flat, measure 40 inches from the end of both long sides, and make a mark—this is where the upright portions of the frame will connect. Position the 20-inch piece of square tubing across the inside of the frame so that it's even with the 40-inch mark. Check for square, tack in place, and then weld. The last 6 inches of the top frame will stick out the end of the cart to serve as a handle. Finish welds smoothly.


1


2

Step 2 Connect top and bottom frames // Cut four lengths of square steel tubing 34 inches long. These will connect the top and bottom frames. Flip the top frame (22 x 46 inches) so it is standing on edge and, using a square and clamps, position one 34-inch upright on the corner and align a second upright with the cross bar at 40 inches. Tack them in place. Then stand the bottom frame on edge, position it at the ends of the two uprights using a square and clamps, and tack it to each of the uprights.

Flip the frame over and position the two remaining uprights between the top and bottom frames. Check for square, clamp, and tack weld in place. Stand the structure up and recheck for square, then weld the joints—alternate corners, and only weld one side of a joint at a time. Finish welds smoothly.



Step 3 Add braces to attach side panels // Cut eight pieces of flat bar stock 6 inches long, then miter cut the ends at 45 degrees. These will brace the corners of each long side of the cart and be used to mount the side panels. Clamp them flush with the inside of the frame, tack in place, and then weld.

Step 4 Add stops for end panel // Cut two pieces of the flat bar stock 20 inches long. These will be installed on the opposite end of the cart from the handle. Align the first one at the top of the uprights, ensuring it's flush with the inside of the frame, then clamp it in place. Tack both ends and weld in a couple places along the top of the frame. Align the second piece inside the bottom of the same two uprights—flush with the inside of the frame—at the bottom and clamp it in place. Tack both ends and weld in place along the bottom as you did the top.

Step 5 Add brackets for propane tank shelf // Cut two pieces of the 1 x 1-inch angle iron 20 inches long. These will mount on the inside of the bottom of the frame on the end opposite the handle. Clamp the first against the end of the frame—flush with the bottom—then tack and weld. Measure 19 inches from the upright along each side of the frame and make a mark. Align the second piece of angle iron on the inside of your mark, clamp even with the bottom of the frame, tack in place, and then weld it in.

Step 6 Add rails to support shelves/pizza dough boxes // Cut two pieces of the 1¼ x 1¼-inch angle iron 36 inches long, which will support the back ends of each rail. These mount vertically on the inside of the frame, 18 inches from the end with the handle and positioned with the flat side facing the handle. Clamp one on each side. Check the measurements from the end and be sure they are square before tacking them in and





fully welding them in place.

Note: We're adding three pairs of rails for two dough boxes and a wooden box made from pallet scraps. You can add more if you like or change the spacing to suit your needs.



6

Cut six pieces of the 1¼ x 1¼-inch angle iron 18 inches long. These will be mounted horizontally to form rails to support shelves for pizza dough boxes. The first two rails will be mounted 6 inches down from the top of the frame. So, measure on the end, beneath the handle, and on the vertical angle iron mid-frame. Clamp, tack, and weld both sides. The next pair of rails will attach 5 inches lower in the same fashion. And the third pair of rails will mount 24 inches down from the top.

Step 7 Build the side panels // The long side panels can be made with the pallet slats oriented either vertically or horizontally. We chose the latter because it created less waste and required fewer slats. The inside dimensions of the frame should be 38 inches by 34 inches. Subtract ¼ inch from each dimension to create a ⅛-inch gap on all sides. So, the panel will need to be 37 ¾ inches wide by 33 ¾ inches tall. Double check your frame dimensions and adjust as needed.

Start by laying out your pallet slats, one above the other, until you've reached the height needed. If you get close, you may choose to space them out evenly, leaving gaps to reach the desired height. We kept them tight and ripped the last slat to fit.

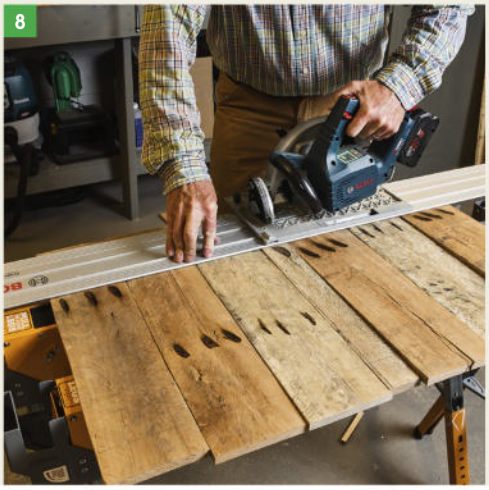
Once you have them laid out and the top and bottom edges are parallel, measure the length (37½ inches) along one edge. Use a square to help mark your vertical cut lines. Measure between opposite corners to be sure the panel will be square—the two measurements should be the same. Now, cut the slats to length. Cut them individually or use a track saw to cut them all at once.

With the horizontal slats cut and laid out, you'll need to connect them all with two vertical slats. Rip the connecting slats into 2½-inch strips for the verticals and bevel cut the ends. Position the slats 4 inches from each end of the panel.

Assembling the panel can be done with screws or nails from the inside or outside—choose the correct-length fasteners for the thickness of your slats. We opted to hide the fasteners and screw them from the back. When the panels are complete, test-fit in the frame and trim as needed.



7







Step 8 Build the end panel // The end panel will be made in the same fashion as the side panels, except it will be 19½ inches wide. Cut your slats to length and lay one above the other until you've reached the height needed—ours is 33¾ inches. Again, space them evenly to reach that height, or keep them tight and rip the last slat to the exact height to fit. Test-fit the panel and trim as needed.

Step 9 Build shelves for the propane tank and dough boxes // Use a piece of ¾-inch plywood for the floor where the propane tank will go. Measure between the two angle iron flanges—it should be about 18 inches, and the width of the frame should be 20 inches. Trim your plywood to fit, about 17½ x 19¾ inches. Then, find the center by drawing lines across opposite corners. Use a compass to draw a circle 8¼ inches in diameter and cut it out with a jigsaw. This will center the propane tank on the floor.

Now, cut two pieces of ¼-inch plywood that measures 17¾ x 19½ inches. Set these between the rails to support the dough boxes.

Step 10 Install rivet nuts for the caster wheels // Remove the side and end panels, as well as the shelves. Flip the frame upside down and position the fixed wheels on the end with the handle—the swivel wheels will go on the other end. Mark the three holes that sit over the frame for each wheel. Then use a 17/32-inch drill bit to make the three holes on each corner. Use the rivet nut tool to install rivet nuts in each hole. Test-fit the wheels using the M8-1.25 x 20mm flanged hex head bolts. Remove wheels to prepare for painting.

Step 11 Paint metal frame and, if desired, stain side panels // Sand the

frame, starting with 150-grit and going up to 400-grit. You don't need to spend a lot of time on the inside surfaces, as those won't be visible once the panels are installed. Focus on the outside edges of the frame. Prime the frame with etching primer, then finish with at least three coats of paint. Finish, seal, or leave the wood side panels natural, if desired.

Step 12 Complete assembly // First, install the caster wheels so the frame will be easier to move around during assembly. Then, drill a 5/32-inch hole in the center of each of the angled corner brackets. Set the first side panel in place, keeping the gap to the frame even around all edges. Fasten with one #8 x ¾-inch truss head screw through each angle bracket (a). Do this for each side.

The end panel needs to be removable so you can access the propane tank. We used four strong, round magnets to hold the panel in place—two on the top and two on the bottom. Use a ⅝-inch Forstner bit to make a round pocket so the magnet will sit flush with the wood. Make sure to line up the pocket with the vertical slat on the outside so the screw for the magnet has enough material to hold.

Drill a single 1-inch hole in the center of the panel near the top. This will allow you to pull the panel off with your finger.

Apply several strips of silicone adhesive to the top of the frame—be sure to get each corner and a couple spots on each side. Recruit a helper to set the stone countertop in place. It should overhang by 1 inch on all sides (b). Let the silicone set overnight.

There is one last hole to drill: Place your pizza oven on top to see where the propane hose is located. Drill a hole big enough to fit the hose through at the top of the side panel. Most have a quick release fitting about 1 to 1¼ inches in diameter.

Install the propane tank shelf and the dough box shelves. Slide in the dough boxes and any other storage boxes you may have planned for, and you're ready to make pizza.





For more project photos and details, visit: popularmechanics.com/diy-pizza-oven-cart

VENONA

From: [redacted]

To: [redacted]

No: 195

9th February

TOP SECRET

[redacted] Inside the [redacted] Top Secret Project That [redacted] Led to One [redacted] of the World's Greatest [redacted] Counterespionage [redacted] Feats [redacted]



THESE FEMALE CODEBREAKERS UNRAVELED A SOVIET SPY NETWORK—AND KEPT IT TO THEMSELVES FOR HALF A CENTURY.

BY JOHN BROICH

1944



GETTY IMAGES (BORDER); COURTESY U.S. ARMY (DECODERS)

In early [redacted] February of 1943,

Gene Grabeel walks toward a corner of a large, crowded room inside Arlington Hall near Washington, D.C. Around her, clutches of people huddle over tables and quietly rifle through filing cabinets.

Only five weeks earlier, the 22-year-old had been working as a home economics teacher in Virginia with no idea her life was about to change. Then she ran into an old acquaintance at a Christmas dance. Frank Rowlett, serving in the Army in the capital, couldn't share details, but he told her there was useful work in the District. The timing was right. Grabeel was disenchanted with her job and her life in a small town of 300, where her mother raised chickens while her father farmed tobacco. Grabeel wanted something more.

Days after the dance, she spoke to a military recruiter in Lynchburg, Virgina, who offered her a job but also couldn't tell her what she'd be doing. She handed in her application anyway, and by the end of 1942, she boarded a train for the capital.

Her destination was Arlington Hall, once a private school for young women that spread across a 100-acre campus on the west side of the Potomac. The U.S. Army had requisitioned it, and the yellow-brick colonial building surrounded by open lawns and landscaped gardens had quickly vanished beneath a sprawl of massive temporary structures, the whole place enclosed by barbed wire. The Signal Security Agency, renamed from the original Signal Intelligence Service that had formed in 1930, had been growing explosively. When Germany invaded Poland in 1939, marking the start of World War II, the entire unit included 19 people. By the time Grabeel arrived, the number had grown to thousands.

Women made up roughly nine in 10 of the workforce at the Agency because the uniformed services had taken so many men for combat. They came from all over the country: language teachers, mathematicians, English majors with a love for puzzles. After their arrival, they underwent a month of hasty training, a crash course in cryptography basics, most of them starting from scratch. At the end of the training, Grabeel was pulled aside for a secret assignment, another mystery in a building full of them.

The only instruction Grabeel receives as she enters the crowded room in February is to speak in whispers. Her supervisor leads her to a small bay with a wooden cabinet that will become her station.

She pulls open a drawer. Inside are folders covered by columns of five-digit number groups. 88537 93422 62085 42537 10293. No words. No context. Drawer after drawer is filled with similar stacks of papers. Grabeel's superior tells her to sort the piles of sheets in front of her—by date and point of origin.

The sheets were encrypted telegrams sent to Moscow from Soviet consulates in New York, San Francisco, and Washington, D.C. In 1943, the U.S. and U.S.S.R. were allies, but a senior Army intelligence officer had ordered their examination largely on a hunch, worried that Joseph Stalin might negotiate a separate peace with Adolf Hitler and leave the Western Allies fighting Germany alone.

The cipher protecting these messages was considered so impenetrable that professional cryptographers in both the Army and the Navy had already tried to break it and quit.

Grabeel didn't know any of that when she was handed what seemed to be a thankless assignment for a program later code-named Venona. She also couldn't possibly know that it would lead to one of the greatest counterespionage feats of the 20th century.



← Gene Grabeel was just 22 when she left her job as a home economics teacher for a top secret assignment in Washington, D.C., where she contributed to one of the most important counterespionage efforts of the 20th century.

As far back as ancient times, governments, merchants, and even lovers have been encrypting confidential messages. Julius Caesar was famous for encoding military communications using a simple substitution cipher. The technique, which would become known as the Caesar cipher, involved shifting each letter of the alphabet by a fixed number of positions—with a shift by five, "A" would become "F," "B" would become "G," and so on.

The Second World War forced combatants across the globe to coordinate vast, far-flung militaries by radio and telegraphy, every transmission susceptible to interception. Navajo code talkers befuddled Japanese eavesdroppers in the Pacific; Germany staked its secrets on the daily-changing, rotor-based, and plugboard-driven Enigma cipher machine; dozens of other methods offered trade-offs in terms of speed, vulnerability, or utility.

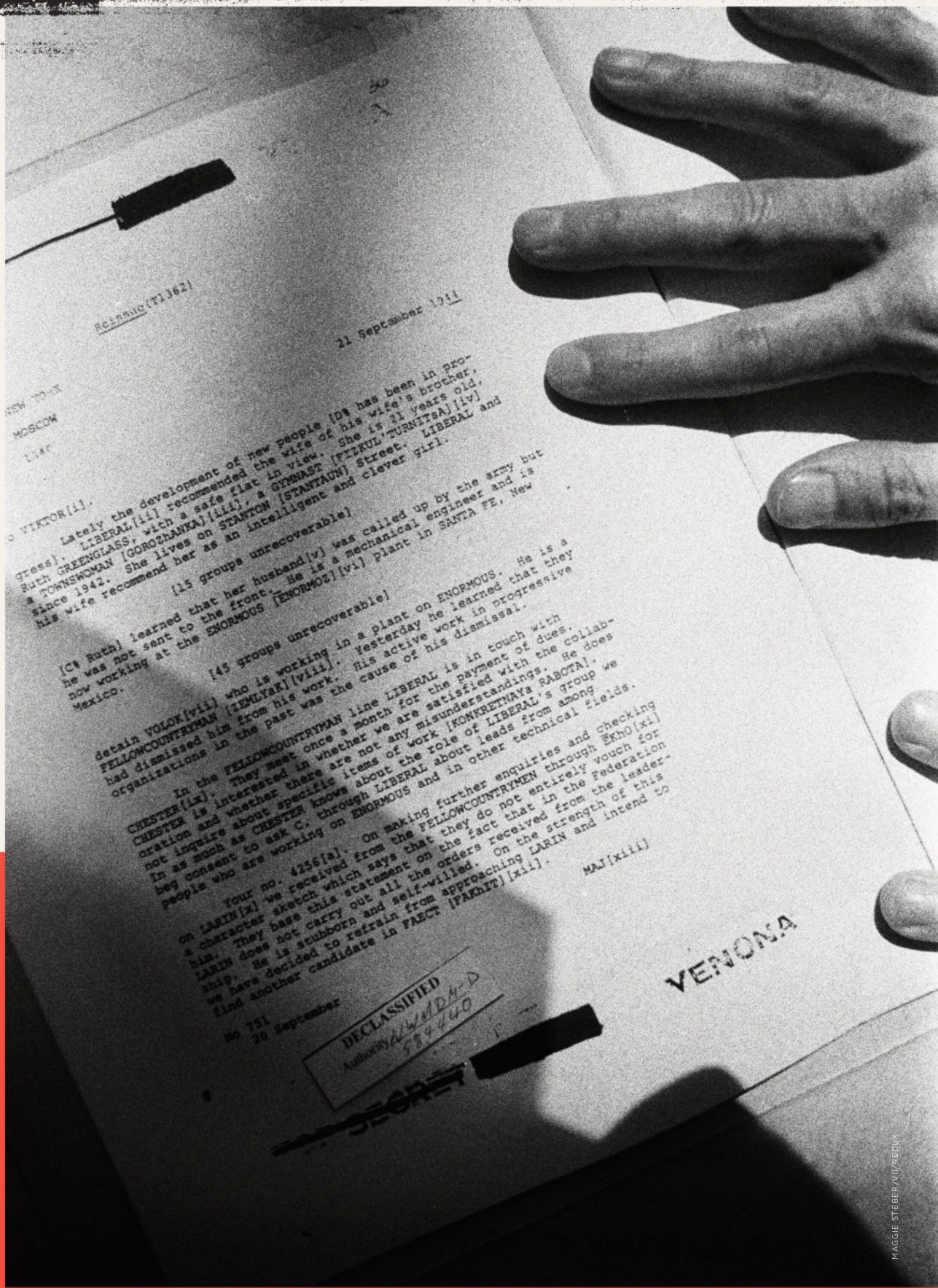
The Soviets, obsessive about secrecy, chose a mode invented in the 1880s called the "one-time pad." The principle was elegant and, in theory, impenetrable. First, a message was converted into four-digit code groups using a codebook of words and phrases: The word "agents" might become 2358, the word "document" might become 7491. But the Soviets didn't stop there. For each code group, the clerk added a random number from a special pad, and this addition transformed the message into double-encrypted gibberish. The pad of random numbers—containing 60, often five-digit, key groups for encryption and decryption—existed in only two copies: one held by the sender, one by the receiver. After a single use, both copies were destroyed.

The mathematics was merciless. Without the key page, decryption was nearly impossible. Each word in the Soviet codebook corresponded to a four-digit number, but before encryption, the clerk regrouped them into five-digit clusters, smearing the boundaries between one word and the next. Then a five-digit figure from the key page was layered on top using noncarrying, digit-by-digit addition. If the U.S. decipherers intercepted a group like 47213, they had no way of knowing whether the original had been 23581 (with 24732 added) or 74916 (with 73307 added) or any of thousands of other possibilities. Even if they could strip the additive, they couldn't tell where one word ended and another began. Because the key numbers were random, there were no patterns. And because each page was used exactly once, there was no repetition.

For months, Gene Grabeel separated messages by origin, date, and telegraph transmission circuit. Code-breaking is not a single flash of insight; it's years of methodical work, building the infrastructure that makes a breakthrough possible. What Grabeel was doing was laying the groundwork.

Her sorting system drew on information that arrived by a circuitous path, the product of one codebreaking effort spilling into the next. Finland, sharing a border with the Soviet Union and having every reason to fear its giant neighbor, had developed an excellent cryptographic staff. While not breaking any Soviet diplomatic ciphers, the Finns had learned enough about their external structure to sort messages into categories, then shared their findings with the Japanese, with whom they bonded over common detestation of

COURTESY NATIONAL CRYPTOLOGIC MUSEUM (GENE GRABEEL)



MAGGIE STEBER/VII/REDUX

← Only a small circle of intelligence officials knew about the Venona project until the mid-1990s, when Senator Daniel Patrick Moynihan's Commission on Government Secrecy declassified the files.

the Soviets. Japanese military attachés in Helsinki then relayed the Finnish findings to Tokyo, and American codebreakers, reading Japanese military traffic, intercepted those reports. After about 10 arduous months, by late 1943, Grabeel and her colleagues discovered five separate Soviet cryptographic channels. Four belonged to users Grabeel could not yet identify, but the fifth, the most voluminous, could be traced to known senders: "Amtorg," the Soviet trading company, and the Soviet Government Purchasing Commission, which managed logistical operations of U.S. supplies during the Second World War. The analysts nicknamed it "Trade."

It would turn out to be the way in.

The team kept growing, and by the summer of 1943, thousands of workers filled Arlington Hall's new barracks and hastily constructed offices. The vast majority bent over Japanese and German codes. The handful of analysts who worked on the Soviet traffic kept apart, sharing what they were doing with no one.

They began experimenting with feeding Trade messages through IBM punch-card machines, the same clunky commercial equipment that large companies might use for payroll, comparing thousands of five-digit groups mechanically, hunting for any sign that the system had a seam. Thanks to this primitive computer, by autumn, Lieutenant Richard Hallock, a peacetime archaeologist from the University of Chicago, discovered what should have been impossible: Some messages appeared to share identical encipherment.

If two messages were encrypted with the same key page, cryptanalysts could subtract one from the other and eliminate the random numbers. It was like discovering that two locked safes used the same combination but still not knowing what the combination was. The outer layer of encryption was gone. Sure, the inner layer remained, but Arlington Hall had found a crack.

After nearly two years of painstakingly sifting for needles in the haystack, they finally started spotting clues buried in every message. The Finnish cryptanalysts, whose findings reached Arlington Hall through Japanese intercepts, noticed that certain number groups appeared in predictable positions in Soviet messages. These indicators existed because every encrypted message carried a practical problem. If you and your correspondent have agreed to scramble your words using a shared book of numbers, you still have to tell them which page you used. You can't send that in plain language, so you tuck it into the message itself, a cluster of numbers that says, in effect, "Use page 14." To a codebreaker who can't read anything else, the indicator is gold.

In November 1944, Genevieve Feinstein and two partners at Arlington Hall figured out how to find it. Feinstein, who a few years earlier had proven herself by helping to crack a Japanese diplomatic cipher that had stumped the experts, noticed that certain opening groups revealed which pad page had been used. Messages that had seemed randomly scattered could now be sorted by their keys. Duplicates began to emerge from the chaos more quickly. What had been impossible labor became, if not easy, at least workable.

Armed with these advances, the team used the gap pried open by Feinstein to reconstruct the KGB codebook itself. Both inside and outside Arlington Hall, a new phase began.

As the Second World War ended in September 1945, the uneasy alliance between the U.S. and the Soviets was fraying. By 1946, the Iron Curtain was falling across Eastern Europe. The Cold War had begun: a contest between two superpowers expanding their spheres of influence while trying to contain each other's, neither trusting the other enough to blink.

Arlington Hall didn't blink, either. The Signal Security Agency, now renamed the Army Security Agency, kept prying into Soviet mail.

The team had now turned to deciphering actual words by working backward from what the numbers could mean. A message might very well contain a date: The analyst could guess it based on sorting, could deduce what code group might represent the Russian word for "April" or "1946." A message originating in Washington, D.C., might contain the four digits for "Washington" or "FBI." The work required intuition, patience, and a willingness to pursue dead ends for months at a time. Yet, word by word, the women of Arlington Hall added to their growing dictionary.

This is where the IBM punch-card machines



played another major role. Mary J. Dunning, who had worked for Army codebreaking since the late 1930s, had invented techniques for hastening brute force attacks on massive piles of data. Encoded Soviet messages were punched onto a stiff rectangular card and then fed through sorters and collators, cabinet-sized machines that compared two decks at several hundred cards per minute, checking for matches. So, when an analyst guessed that a certain message contained the code group for "April," the machines could test that guess across thousands of messages in hours. If the same group turned up repeatedly in messages known to have been sent in April, the hypothesis held. Each confirmed guess became a new card in the library deck, and each new card made the next round of machine runs more productive. Unlike today's computers, the machines had no memory, but they could work at a pace that made a difference in years. By the end of 1946, the Venona team had run comparisons on 750,000 cards.

With this technology, the cryptanalysts pried open the codebook's "spell table," the system the KGB used to transliterate English names and words not contained in the codebook. With Russians using the Cyrillic alphabet, English names had to be converted letter by letter, then encoded. Cracking the spell table meant they could now read the names of Soviet spies in America.

Up until now, the team's work was invisible, but that was about to change.

On March 4, 1949, Judith Coplon was crisscrossing through Manhattan in a peculiar way. She rode the subway, got off, got back on. Switched cars. Took a bus for three blocks, then got out and walked. Checked reflections in storefront windows. To someone familiar with the techniques of spycraft, it was obvious she was one.

Coplon, a Barnard College graduate, was employed by the Justice Department, but at that moment, she was on her way to meet Valentin Gubitchev, a KGB officer working undercover as a United Nations employee. The FBI had been following Coplon for months, tapping her phone and finally setting a trap, hoping to prove her connection to the KGB. And they were on her heels now.

Through 1947, Venona analysts translated dozens of messages revealing that Soviet intelligence

MAGGIE STEBER/VII/REDUX (AWARD); ASSOCIATED PRESS (JUDITH COPLON)



← Soviet spy Judith Coplon leaves New York's federal court on March 15, 1950, with her attorney Sam Shapiro, right, and her brother Bertram Coplon. Opposite: Gene Grabeel receives a certificate from the National Security Agency.

officers in New York and Washington were running networks of American sources who passed classified documents to Moscow. The messages were full of cover names: REST, a scientist. ALES, a diplomat. LIBERAL, an engineer. Arlington Hall shared the messages with the FBI, which began its own methodical work of profiling potential spies.

One shadowy form among the cables was especially troubling. The messages about SIMA indicated a Soviet agent inside the Justice Department. Clue by clue, the decrypted messages colored in the silhouette: an employee in the Foreign Agents Registration section, recruited in late 1944, recently moved to the District, studying Russian to improve their access to Soviet-related files. By December 1948, the FBI had homed in on Coplon. If the identification was correct, she had spent nearly four years giving Moscow early warning of FBI counterintelligence operations.

When agents finally stopped Coplon, they found Justice Department counterintelligence files in her purse that they had purposely routed through her office.

But the Bureau faced a problem that would haunt every Venona case. The decrypted cables couldn't be used in court. Revealing that the U.S. had broken the Soviet cipher would alert Moscow to change its systems, and the flow of intelligence would stop. For that reason, prosecutors could not explain how they had first suspected Coplon, and her eventual conviction was overturned.

Still, the flow of information from SIMA was stopped—and the secret held.

The successes continued. When Venona identified German-born physicist Klaus Fuchs, who lived in England, the scale of what the Soviets had stolen came into focus. Fuchs had worked at the heart of the Manhattan Project in Los Alamos, New Mexico, and he had passed Moscow detailed plans for building an atomic bomb, including the key engineering breakthrough that made the plutonium bomb possible. The FBI shared the identification with Britain's MI5, a domestic counterintelligence and security agency. Under interrogation, Fuchs confessed and named his courier, Harry Gold. Gold named David Greenglass, a machinist at Los Alamos, who turned on his own brother-in-law, American Julius Rosenberg, a defense engineer who ran his own spy ring. Each domino toppled the next, building a chain of testimony that held up in court. Rosenberg, together

The work required intuition, [redacted] patience, and a willingness to pursue dead ends for months at a time. Yet, [redacted] word by [redacted] word, the women of Arlington Hall added to [redacted] their growing dictionary.



↑ Gene Grabeel (left) and other cryptanalysts at the Declassification and Release Ceremony for the Venona Project on July 11, 1995.

with his wife, Ethel, went to the electric chair in June 1953, having never heard the word Venona. Neither had the jury that convicted them, nor the judge who sentenced them.

In some instances, Venona's secrecy interfered with justice, and few paid a higher personal price than Elizabeth Bentley. In the fall of 1945, the manager at a Soviet front company, the U.S. Service and Shipping, walked into an FBI office and confessed to serving as a courier for Soviet intelligence networks, collecting documents from government employees, and passing them to her KGB handler. She named dozens of officials in the Treasury Department, the State Department, and the Office of Strategic Services and gave the FBI a detailed statement of more than 100 pages. But Bentley had no physical evidence, and her word stood alone against that of respectable government officials. One scholar later wrote that the consensus view held her charges to be the "imaginings of a neurotic spinster." The Venona messages, had they been released, would have proven her right: The cover names she provided matched cover names in the decrypted cables. Bentley died in Connecticut in 1963 having never learned that her testimony had been vindicated.

Over nearly four decades, the project that Gene Grabeel started partially decrypted some 3,000 Soviet messages and exposed 349 Americans with covert ties to Soviet intelligence. Only a handful were prosecuted; more than 100 were quietly forced out of government jobs or otherwise neutralized, never knowing how they'd been found out. The work continued until October 1, 1980, when the National Security Agency concluded the material had been squeezed dry and shut down the Venona project. The cables themselves stayed classified for another 15 years. Nobody outside a small circle of intelligence officials—not even sitting presidents—knew the project had ever existed until Senator Daniel Patrick Moynihan's Commission on Government Secrecy finally laid the files open in the mid-1990s.

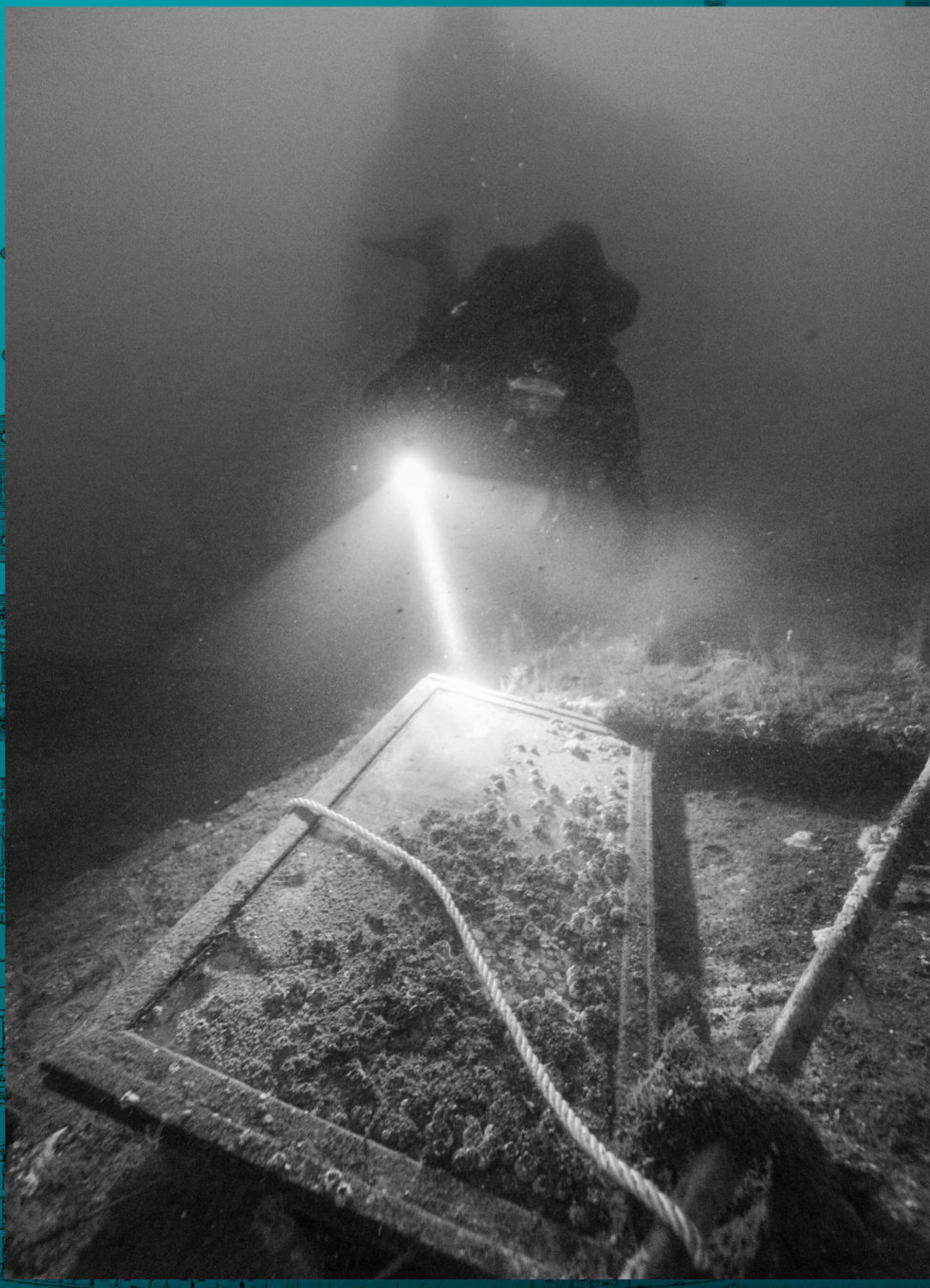
Only later would the Americans learn what made the breakthrough possible. After Hitler invaded the Soviet Union in June 1941, message traffic from Soviet embassies and intelligence stations exploded overnight. Cryptographic offices in Moscow couldn't manufacture one-time pads fast enough, and Soviet officials faced severe consequences, sometimes fatal ones. It's unclear who slipped up: an official scrambling to meet quota, or a clerk who simply improvised under impossible pressure. But for a few months in early 1942, the KGB's cipher office duplicated more than 35,000 pages of one-time pad key material. The Kremlin's unbreakable cipher had developed an invisible crack. The duplicated pages were scattered among millions of legitimate ones, used by code clerks in different cities, months or even years apart. And the women behind the Venona project noticed.

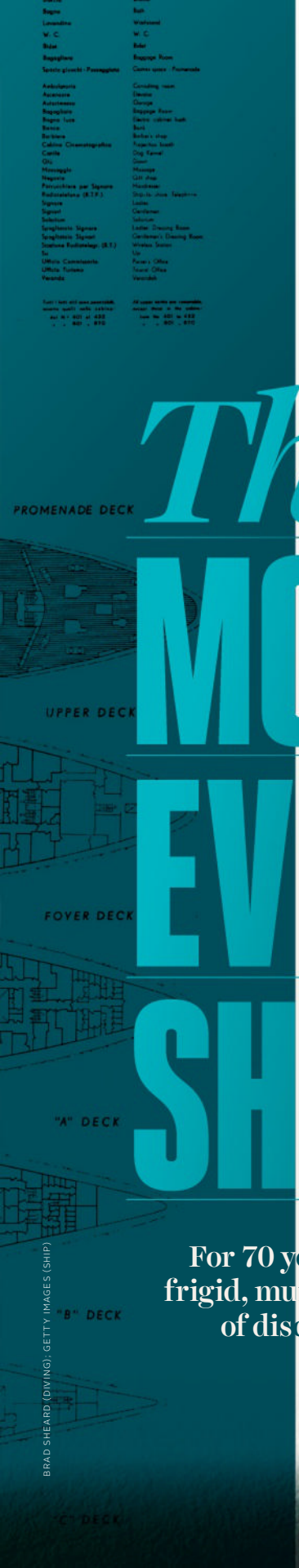
In July 1995, 52 years after the project began, the surviving members of the codebreaking team finally received their recognition while attending a ceremony at the CIA headquarters, white-haired retirees who had kept the secret for half a century. Gene Grabeel was among them.

It took two more years to release the full haul. The public finally saw what had been hidden: not just the spies, but the people who caught them, women from all across the U.S., who had spent months sorting encrypted gibberish because no one told them the task was impossible. PM

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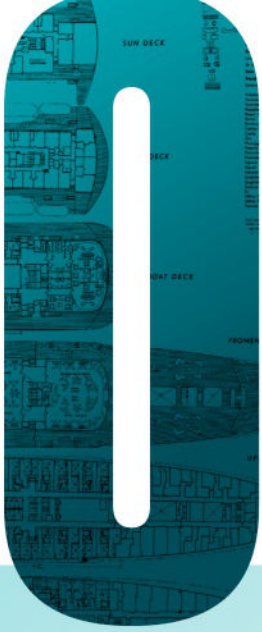


The MOUNT EVEREST of SHIPWRECKS

For 70 years, the *Andrea Doria* has lured divers into the frigid, murky waters of the North Atlantic with the promise of discovery—and the very real possibility of death.

BY LAURA CASTAÑÓN

BRAD SHEARD (DIVING); GETTY IMAGES (SHIP)



▶ The *Andrea Doria* stayed afloat for nearly 11 hours after being struck by the *Stockholm*.

ON AUGUST 4, 1998, MIKE DUDAS GOT HIS FIRST look at the wreck of the *Andrea Doria*. Lying on her starboard side in the cold Atlantic waters about 50 miles south of Nantucket, the 700-foot cruise liner stretched into the blue-green darkness far beyond the limits of his vision.

Described by *Life* magazine as a "floating guide to art," the S/S *Andrea Doria* was a flagship of the Italian Line, a line of luxury passenger ships that sailed between Europe and the United States. The design boasted three outdoor swimming pools, multiple ballrooms, spaces for indoor and outdoor games, and extravagant first-class staterooms individually decorated by Italian artists. Paintings, tapestries, ceramics, and other works of art adorned the ship's public areas, and the dining tables were set with etched crystal and fine Italian porcelain.

"Into every detail of this lovely vessel have gone the skill and pride of the greatest artisans of Italy," read one advertisement. "Every mural, every tapestry, every rug and chair...each exquisite bit of glassware and every glowing tile is the work of craftsmen."

On July 25, 1956, the *Andrea Doria* was nearing completion of her 101st transatlantic crossing. The ship had left Genoa, Italy, with 1,706 passengers and crew eight days earlier and was due to dock in New York City the following morning. By 10 p.m., many of her passengers had gone to bed, although some were making the most of their last night at sea, betting on mechanical horse races and playing bingo in the first-class lounge, dancing to an eight-piece orchestra, or watching the movie *Foxfire* on a screen set up in the tourist-class dining room.

On the bridge, Captain Piero Calamai had joined the officers on watch. That afternoon, the *Andrea Doria* had steamed into a thick bank of fog, and at times visibility was practically zero. Calamai had slowed the ship from 23 knots to 21.8, but he had a deadline for arrival in New York. With the cruise liner's watertight doors sealed and the foghorn blasting at regular intervals, Calamai had posted an extra lookout on the bow but was relying on the radar for advanced hazard warning.

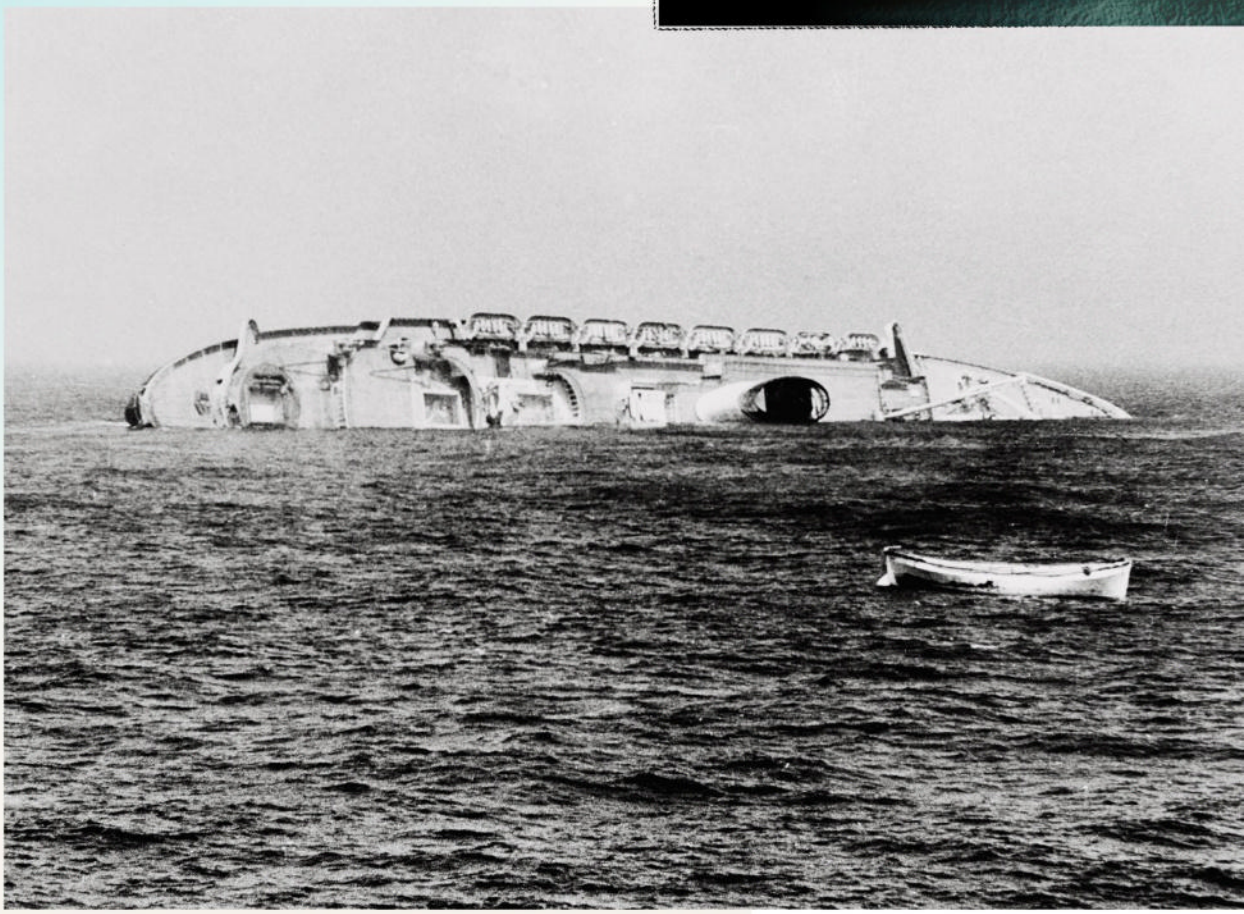
At the same time, a smaller cruise liner was outbound from New York City, heading for Gothenburg, Sweden. The M/S *Stockholm* was just over 520 feet long, carrying 534 passengers and more than 200 crew members. Captain Harry Gunnar Nordenson had chosen to follow his usual route out of the Long Island Sound, aiming to pass within a few miles of the *Nantucket Lightship*—a vessel anchored as a floating lighthouse to mark the dangerous shoals south of the island. This was some 20 miles north of the recommended route for outbound traffic, but it would save both time and fuel—important commodities in the cruise industry.

At about 10:45 p.m., a blip appeared on the *Andrea Doria*'s radar screen, roughly 17 nautical miles away. The dot was a few degrees to starboard, and Calamai assumed it was a fishing trawler heading toward Nantucket.

On board the *Stockholm*, third officer Johan-Ernst Carstens-Johannsen was in charge of the bridge. The 26-year-old had orders to summon the captain if the ship encountered fog, but from his perspective it was a clear, moonlit night. The fogbank on the horizon was invisible in the dark.

The *Stockholm*'s radar picked up the *Andrea Doria* a bit before 11 p.m., when the ship was about 12 nautical miles away. Carstens-Johannsen took two radar bearings, recording the approaching ship's angle and distance a few minutes apart. With this information, he calculated that the other ship would pass within a mile to the *Stockholm*'s port side—too close for comfort. Carstens-Johannsen was right to be concerned, but wrong about the angle.

Radar was a relatively new technology at the time and could be inaccurate by several degrees. Adding to the confusion, the *Stockholm's* helmsman, Peder Larsen, was on his first voyage with



BETTMANN / GETTY IMAGES

the ship and was struggling to steer a straight course, yawing several degrees to either side of the assigned heading and making it hard to record accurate bearings. Later analysis of the collision would show that the *Andrea Doria* was actually on track to pass slightly to starboard, not port.

At 11:05, Calamai ordered a 4-degree turn to port aboard the *Andrea Doria*, believing this would widen the gap between the two ships. International regulations required that ships approaching each other head-on both turn to starboard to pass safely, but Calamai (who was watching the radar but had not plotted the approaching ship's course) assumed the supposed fishing trawler would continue straight and pass safely to starboard.

At 11:07, Carstens-Johannsen ordered a 20-degree turn to starboard aboard the *Stockholm*.

At 11:10, with less than a mile separating them, the two ships could finally see each other's lights through the fog. They were on a collision course. Carstens-Johannsen ordered the *Stockholm*'s helm hard to starboard and the engines to full reverse. Calamai ordered the *Andrea Doria*'s helm hard to port.

But it was too late.

Less than a minute later, traveling at 18.5 knots, the *Stockholm* plowed into the *Andrea Doria*'s starboard side. The *Stockholm*'s reinforced bow, designed to fend off ice in northern harbors, stabbed some 40 feet into the larger Italian ship, rending open seven of the *Andrea Doria*'s 11 decks just aft of the bridge. (One passenger on the *Stockholm* described the ship coming to a sudden stop followed by a "crunching sensation.") The two ships remained connected for a moment, dragged forward by the *Andrea Doria*'s momentum, before the *Stockholm* tore free and the sea rushed in.

Forty-six passengers aboard the *Andrea Doria* and five crew members on the *Stockholm* were killed as a result of the collision. Within minutes the *Andrea Doria* began listing heavily in the waves, but she would stay afloat for nearly 11 hours—enough time for nearby ships to rescue the remaining passengers. The *Stockholm* limped back to New York, its bow in tatters. And the next morning, just after 10 a.m., the *Andrea Doria* sank beneath the waves.



PHOTOGRAPHY BY TREVOR RAAB

◀ Tom Packer's personal collection of photographs documenting his dives to the wreck. ▶ Steve Gatto recovered the *Andrea Doria*'s helm in 1987. It has since been restored and is on display in Gatto's home.



Almost immediately, intrepid divers set their sights on the wreck. The day after the ship sank, two amateurs, Peter Gimbel and Joseph Fox, made the descent. Armed with wetsuits, rudimentary dive gear, and an underwater camera, the two friends paid a Nantucket fisherman to take them out to the site. The water surface was slick with oil, and air still bubbled from the wreck as the men dragged themselves down the anchor rope of a Coast Guard buoy marking the spot.

Gimbel took only a handful of photos of the sunken liner before Fox started having trouble, likely because his dive gear wasn't up to the task. Gimbel helped him back to the surface, where he was able to recover.

The close call did not deter Gimbel, who would return to the *Andrea Doria* many times over the following years, selling his photos to *Life* magazine and filming two documentaries about the ship. The *Andrea Doria* was remarkably intact, and Gimbel's early exploits showed that she could be reached. It was only a matter of time before other divers followed.

In 1964, two businessmen funded an expedition to retrieve the life-size bronze statue of Admiral Andrea Doria from the ship's first-class lounge. They brought up most of it, cutting the statue off at the ankles and leaving behind the feet and base, which were bolted to the deck.

In 1981, Gimbel and his team cut a hole into the *Andrea Doria*'s hull to retrieve the ship's three-ton safe, rumored to be filled with diamonds and other jewels worth over a million dollars. (It actually contained a small number of bank notes and traveler's checks.) But many of the *Andrea Doria*'s treasures are smaller items scattered in the chaos of the collision—a silver jewelry box, a charm bracelet, a makeup compact—along with caches of elegant gilt-edged porcelain from the first-class dining rooms.

Over the decades, the wreck of the *Andrea Doria* became known as the Mount Everest of diving, in part because of its bucket-list allure, but also because of its very real risks. Since the ship went down, 18 divers have lost their lives trying to explore the sunken liner—making it one of the most treacherous shipwrecks on the East Coast.

So why do divers keep coming? For some, it's the challenge and the rare opportunity to explore a place that few people will ever see. For others, it's the possibility of unearthing priceless artifacts or the satisfaction of salvaging what remains of an extraordinary piece of history. But after 70 years on the seafloor, the *Andrea Doria* is a collapsing husk of her former glory. Whole decks have crumbled, pieces of the bow and stern have fallen off, and the entire wreck has lost some 30 feet in height. It's only a matter of time before there's little left to explore.

THE 1990S WERE A PARTICULARLY BAD SET OF years for *Andrea Doria* divers. Between 1992 and 1999, eight men perished while exploring the wreck. "It seemed like somebody was dying on every trip," says Tom Packer, who has been diving the wreck since the early '80s and often crewed charters to the *Andrea Doria* with his dive part-



▲ Mike Dudas's parents, Evelyn and John, after retrieving the ship's main compass in 1967. The restored artifact is currently on display in his family's living room.

ner Steve Gatto. "We would look around and go, 'Who's not coming back?'"

The ship rises up some 80 feet from a seabed that is 250 feet below the surface, well beyond the reach of recreational divers. At those depths, the human body experiences six to eight times more pressure—and consumes roughly six to eight times more air—than at the surface. The additional pressure makes it easier for air inhaled at depth to dissolve into the bloodstream and tissues, where different gases can cause a variety of issues including narcosis, oxygen toxicity, and decompression sickness (also known as the bends).

Doria divers must plan carefully to avoid these hazards and carry additional tanks of compressed air. Divers approaching the wreck experience limited visibility and powerful currents that can exhaust even the most seasoned. Those venturing inside during the '90s would have encountered a maze of sideways stairwells and collapsing hallways filled with decaying metal and dangling wires, every surface covered in a thick layer of silt billowing up in turbid clouds when disturbed.

In 1996, Gatto and Packer became the first divers to reach the *Andrea Doria*'s engine room. Both men were experienced *Doria* divers, but Gatto still had a close call. They had plotted out the dive meticulously, and everything was going to plan. They had entered the cavernous ventilation shaft, passing the remains of catwalks, pipes, and steel beams, and found the engine room's massive gauge panel. Packer hung back while Gatto, who had been filming the dive, swam up and down the panel to capture the telegraphs, throttle wheels, and circular glass gauges. With his focus on the camera, Gatto momentarily lost track of where he was. He turned away from the panel, expecting to see the hole he had swum through. Instead, there was a wall.

"For a brief moment in time, it was just that heat that goes through your body," Gatto says. "And you're like, 'Oh, this is bad.'"

Gatto immediately started feeling the effects of narcosis. "Getting narced" is a hazard for any deep-water diver breathing compressed air. When inhaled nitrogen dissolves into the blood and tissues, it can cause feelings of euphoria or disorientation, slow critical thinking, and affect memory and coordination. Anxiety increases the risk of narcosis, as does cold water.

Gatto went back to the gauge panel in an attempt to orient himself, turning his back to it and slowly swimming forward. He had been exploring the *Andrea Doria* for more than 10 years at this point and knew to move slowly and methodically, even if he was having difficulty focusing. He tried to signal to Packer that he was in trou-

COURTESY MIKE DUDAS (BLACK AND WHITE); TREVOR RAAB (COMPASS)

ble but couldn't collect his thoughts well enough to communicate.

Gatto described the experience later, narrating over video footage of silt-covered metal and drifting debris. "Random pieces of information were skipping around my brain. I was still struggling to put my thoughts in some kind of order."

He snapped back into focus when he caught a glimpse of one of the strobe lights the divers had left to mark their route. Gatto was able to slowly work his way back out of the ship and await Packer on the outside of the hull.

The desire to take home a small piece of the famous ship has lured many, even those with limited experience exploring complicated wrecks in cold and murky Northeast waters. By the 1990s, the dive community was buzzing with stories of *Doria* divers emerging from the water with bags full of fine porcelain dishware or pieces of ceramic artwork. With obvious caches of the sought-after dinnerware already emptied, divers needed to go deeper or find unexplored parts of the ship from which to unearth a prize.

At the same time, advances in diving technology made the wreck seem more accessible than ever. Standard protocol had been to carry tanks of compressed surface air (78 percent nitrogen, 21 percent oxygen). The introduction of mixed-gas diving—in which users could replace some nitrogen with helium to reduce narcosis—allowed divers to go deeper and think more clearly at depth. What had once been the domain of a small group of highly experienced Northeast wreck divers began to attract a wider crowd, not all of whom were prepared for the cold water, swift currents, and other challenges of a *Doria* dive.

"Suddenly anybody who could afford it started filling their tanks with some sort of helium mixtures and wiping out the narcosis," Packer says.

Gatto, who has made more than 250 dives to the *Andrea Doria*, believes "they were substituting technology for experience."

And the new tools came with their own hazards. Mixed gas didn't reduce all risk and added another level of complexity to the endeavor. *Doria* divers still needed to make long decompression stops at various depths on their way to the surface to avoid decompression sickness, and the deeper or longer they stayed, the more crucial those stops became.

To manage it, divers started carrying a variety of tanks with different gas mixes—low-oxygen mixes for deeper depths, and higher-oxygen mixes for decompressing. Used correctly, the system worked. Used incorrectly, it could be fatal. At depth, too much oxygen could trigger seizures or a sudden blackout; in an emergency, a diver grabbing the wrong bottle might not realize the mistake until it was too late.

Gatto and Packer emerged from their near miss in the engine room unscathed and triumphant. They didn't have much to show for it—only a couple of innocuous brass handles from the two telegraphs, barely three and a half inches long. But they had ventured someplace no one else had been since the night the *Andrea Doria* sank and had returned to tell the tale.

WHEN MIKE DUDAS MADE HIS MAIDEN DIVE ON August 4, 1998, and saw the *Doria* stretched out in front of him in the murky depths, he thought, "Boy, I get it." The size and majesty of the Italian luxury liner, even in her decaying state, was unlike any other East Coast shipwreck he had visited. Dudas, whose family owned a dive shop in Pennsylvania, grew up surrounded by stories of the *Andrea Doria*. In 1967, his mother had been the first woman to dive the shipwreck, and his father had retrieved the ship's main bridge compass, which had been in his family living room as long as he could remember. The sunken vessel was considered the pinnacle of wreck diving in the Northeast, and he was finally seeing it for

SINCE THE SHIP WENT DOWN, 18 DIVERS HAVE LOST THEIR LIVES TRYING TO EXPLORE THE SUNKEN LINER.

"THE *DORIA* HAD THIS ALLURE. SHE JUST KEEPS GIVING IN A WAY THAT A LOT OF OTHER SHIPWRECKS DON'T."

himself. "This is like nothing else," says Dudas.

There were two charter boats at the wreck that day—a pile of dishware had been discovered earlier in the summer, and everyone was on the hunt for more. But Dudas stayed outside the sunken ship, using her bulk to shield himself from the current as he swam slowly down the promenade deck. For 15 minutes, he was alone with the *Andrea Doria*, marveling at the wreck he'd heard so much about. Then he returned to the anchor line to meet the other divers from his group and ascend to their first decompression stop on the way to the surface.

Back on their boat, Dudas and the other divers from his charter ate lunch, allowing time for any residual gases in their bodies to dissipate. They planned to make another dive in the afternoon.

Then, a body floated to the surface.

It was one of the men from the other charter.

Divers rushed to get him on board that boat, pulling off his tanks and cutting away gear to start CPR. But the man remained unresponsive. Several hours later, he was airlifted off the dive boat by a Coast Guard helicopter.

Vince Napoliello, a 32-year-old stockbroker and experienced *Doria* diver, was pronounced dead at Cape Cod Hospital that night. He was the tenth person to die diving the *Andrea Doria*; the third in less than two months.

The divers on Dudas's charter opted to get back in the water the next day. Dudas was able to borrow a phone to call his mother and leave a message: "Hey, if you hear anything, it's not me. I'm okay."

He knows that wreck diving is a dangerous hobby—his father died while diving in 1982, when Dudas was still young. Improved protocols and training have certainly made things safer, but it will always be more dangerous than staying home.

JENNIFER SELLITTI IS THE MANAGER OF ATLANTIC Wreck Salvage, a group that locates and recovers artifacts from shipwrecks. Since 2010, the outfit has made annual trips on their dive boat, the D/V *Tenacious*, to the *Andrea Doria*, retrieving numerous items, including the ship's foghorn in 2017. Her team makes a point of restoring salvaged artifacts and sharing them with the public.

"The *Doria* had this allure," says Sellitti, 52, whose day job is leading the public defender's office for the state of New Jersey. "She just keeps giving in a way that a lot of other shipwrecks don't."

Sellitti is warm and confident, and has never been good at sitting idle. In addition to her shipwreck work and her full-time job, she keeps goats, cows, and ducks on a small farm, is in the midst of a home renovation, and just finished writing a book. Her hobby of choice used to be ice climbing, but she was swept into the world of wreck diving by her partner, Joe Mazraani, and quickly became captivated by the history behind each wreck. She soon found herself earning her captain's license, running the ship with Mazraani and providing surface support for the divers.

She acknowledges the dangers of diving the *Andrea Doria* and other North Atlantic wrecks. "It's a volatile environment," she says. "There are very few people who have the diving skills, the logistical capabilities to get out there and make these dives."

Mazraani, a fierce defense attorney on land and gruff captain, shipwreck hunter, and technical diver at sea, was one of them. Chris Ogden, a construction superintendent with sleeve tattoos and an infectious energy, was another.

On July 11, 2025, Ogden was 230 feet below the surface when he saw something that made him catch his breath. The 36-year-old had swum into a crevice in the decaying hull of the *Andrea Doria* and was hoping to find a way to retrieve a brass window from a tangle of wires and fishing nets. But

►► The restored and polished stern bell of the *Andrea Doria*. ► John Moyer with one of the largest artifacts to come off the wreck, the now-restored bronze statue of the ship's namesake, Admiral Andrea Doria.

as he panned his light across the debris, he spotted a distinctive circular shape—the top of one of the ship's gyrocompass repeaters.

"I was like, 'Holy shit, that's the compass,'" Ogden says. "I started freaking out...I just wanted to get up and tell Joe." The five-foot-tall brass navigation instrument would have stood on the *Andrea Doria*'s port bridge wing, displaying the ship's heading on her last day afloat.

Buzzing with excitement, Ogden cut his dive short and made his way back to the surface, waiting impatiently at his decompression stops.

Mazraani, meanwhile, already knew about the compass. He had spotted it on his own dive half an hour earlier. As Ogden pulled himself up onto the boat's swim platform, Mazraani allowed himself a grin. "What did you find, Chris?" he asked.

"I found the compass!"

"So did I."

Ogden could hardly believe they had both been in the same tight, tangled spot. "Nobody in their right mind would ever find this thing," he says. But Mazraani described the exact location.

"Congratulations, it's yours," Ogden said. "But it's coming up. We're getting that thing up."

Mazraani was game to try but had his doubts. The compass was buried in the bowels of the wreck, trapped under massive amounts of debris.

"There's no way this is coming up this trip," he told Sellitti as they walked into the cabin. "No way."

SHIPWRECK SALVAGE CAN BE CONTENTIOUS. SOME argue that the historic artifacts should be left in place or only retrieved by archaeologists. But *Doria* divers point out that the wreck is difficult to reach and rapidly deteriorating. Any items not found are likely to be lost in shifting sand and debris, never to be seen by anyone.

John Moyer started diving the *Andrea Doria* in the early '80s and, after helping to retrieve the ship's stern bell, began researching the vessel in more detail. What started as a way to learn about





TREVOR RAAB


BELL SALVAGE TEAM
This bell was recovered in 1985 from the Auxiliary
eering Station in the stern of the wreck by Gary Gentile,
Art Kirchner, Mike Boring, Tom Packer, Kenny Gascon,
Bill Nagle, and John Moyer.


ANDREA DORIA

◄ A photo displayed in John Moyer's home of the team that discovered the ship's bell in 1985. ▼ *Andrea Doria* deck plans in Tom Packer's basement alongside his dive gear.

what else he could recover quickly grew into a fascination in the ship's history.

Over the years he has corresponded with engineers and shipwrights, met with survivors, and collected binders full of historical documents. He, along with Packer and Gatto, also holds the salvage rights to the ship, which he acquired as part of a large-scale operation to retrieve two massive ceramic friezes by sculptor Guido Gambone that had once been mounted in the ship's Winter Garden lounge.

"Two years later...the Winter Garden was completely gone," Moyer says. "If we hadn't recovered the panels in 1993, they would have been lost forever."

Moyer, along with fellow diver Gary Gentile, is also responsible for reuniting the bronze statue of Admiral Andrea Doria with its original feet and base, which they retrieved from the wreck in the '90s. The men acquired the rest of the statue in 2024 from the family of the captain who led the 1964 recovery, and had it restored to like-new condition, with the addition of a single barnacle still attached to the base. The admiral towers in the corner of Moyer's living room, standing watch over the rest of his collection.

Now in his 70s, Moyer has retired from diving, but his home is filled with evidence of his fascination with the Italian liner. Artifacts from his dives fill display cases and decorate the walls, along with other items that he has been gifted or purchased at auctions. He even has a copy of *Popular Mechanics* from 1958 with an article titled "How We'll Raise the *Andrea Doria*." (Spoiler: We did not.)

In 2025, he loaned out a small portion of his collection—including a deck chair, a life jacket worn by a young passenger the night of the collision, and a 140-pound brass bell—to the Italian American Museum in New York City for an exhibit on the ship's final voyage.

Moyer sees himself as a temporary custodian of these artifacts. But he'd like them to have a permanent home.

"I'm hoping to find some museum that will want to...have some big *Andrea Doria* exhibit," Moyer says. "That's always been my goal, to recover this stuff, put it on public display."

RETRIEVING THE *ANDREA DORIA*'S GYROCOMPASS

this past July would turn out to be Mazraani's last contribution to salvaging what remains of the ship.

He and Ogden had four more dives planned over the two and a half days that remained in their expedition, each limited to barely 40 minutes on the bottom. The compass was buried in debris in a small space maybe five feet in any direction and surrounded by jagged metal.

The first step was to remove the fishing nets that hung throughout the area, threatening to snag anything that moved. "If you didn't clear the nets...you probably wouldn't get out," Ogden says.

Once they had cut the nets free, the men returned with any tool that might be useful—crowbars, hammers, wedges, a knife duct-taped to a boat pole—to start excavating pipes, cables, and chunks of the ship's hull.

"We probably put a pile outside the room that was eight-foot-high by 10-foot-long, five-foot-wide. That's how much debris we had to pull out," Ogden says.

It took the better part of three dives to clear the space. The five-foot-tall brass cylinder of the compass was attached to a base trapped under several

"IT'S A VOLATILE ENVIRONMENT. THERE ARE VERY FEW PEOPLE WHO HAVE THE DIVING SKILLS, THE LOGISTICAL CAPABILITIES TO GET OUT THERE AND MAKE THESE DIVES."

TREVOR RAAB



▲ Jennifer Sellitti (front) and Joe Mazraani (right) with the crew after retrieving the gyrocompass repeater in July 2025.

THE FACT THAT THE WRECK KEEPS CHANGING IS PART OF HER DRAW. EACH COLLAPSED SECTION AND RUSTED HULL PLATE REVEALS TANTALIZING POSSIBILITIES.

large cables. After consulting with Mazraani, Ogden swam through a small hole in the side of the room to pry the cables free with a crowbar. The space was too narrow for him to turn around when he was finished.

"Before we planned that dive, I told Joe, 'You're gonna need to pull me out fins first, because I won't have room to wiggle my way out backwards,' and that's exactly what happened," Ogden says. He still felt things catching on his gear as Mazraani pulled him free. "That's literally putting your life in somebody else's hands."

With just one dive left, the pair realized there were too many sharp pieces of metal to run straps across and out the top hole. They would need to tip the compass over and drag it out sideways.

It stretched their time on the bottom, but they managed to get the compass in place rigged with straps, which led outside the ship to a lift bag rated

COURTESY ATLANTIC WRECK SALVAGE (TEAM)

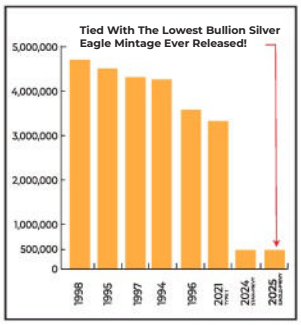


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◀ John Moyer holds a piece of the Gambone panels recovered in 1993, along with a collection of the ship's china.

to hoist 500 pounds. Mazraani filled the bag with air from a spare tank, and as it rose toward the surface, the compass quickly started to break free.

"It almost took me out," Ogden says. "I swam for my damn life, and the next thing you know, the thing rips through a wall in the room and it's out."

The compass was in the clear, held taut between the lift bag straining toward the surface and a line the men had tied to keep it from ascending before they were ready. As Mazraani began his ascent, Ogden tied a reel of line to the compass, made sure the way to the surface was clear, and cut the rope holding the artifact down. The compass shot upward, picking up speed until it reached the surface less than a minute later. Ogden tied the line off to the wreck, collected their tools, and started his own ascent behind Mazraani.

When Mazraani emerged on the surface, Sellitti was filming. He climbed quietly onto the boat—he was always a bit cranky coming out of the water, Sellitti says, no matter what happened.

"Look at the grumpy face," she joked from behind the camera. Then, after a pause, "Words?"

Mazraani answered with the barest hint of a smile, "That was fun."

The gyrocompass emerged mostly intact, missing only the face marked with degrees and cardinal directions to indicate the ship's heading.

And there was a mysterious scrap of rope tied around the binnacle, evidence that some other diver had been there previously. But who?

Mazraani never had the chance to find out. He died unexpectedly on July 29, 2025, at the age of 47, after suffering a medical emergency while exploring an unidentified wreck on the eastern edge of Georges Bank, some 200 miles off of Cape Cod. Sellitti and her fellow divers sounded the *Andrea Doria*'s foghorn at his memorial.

"Joe was obsessed with finding out who tied that rope," Sellitti says. "The day before he died, we had a whole conversation about it."

Less than a week later, Sellitti got a call from Al Giddings, who had been part of an expedition to the *Andrea Doria* with a group of Italians filming a documentary in 1968. He had seen an article about the compass retrieval.

"I'm gonna tell you something about your gyrocompass repeater," he said. "It has everything except the face...because the face is in my living room."

Sellitti started to laugh. "The first order of business for Joe was to let us all know who tied the string around the compass," she says. It felt like a sign.

Despite 70 years of decay, the *Andrea Doria* continues to call to divers, though perhaps not as loudly as she once did. Reaching her aging hull is a badge of honor, and there is still the sense that she hides more treasures within her crumbling walls.

"The *Doria*, to this day, has that allure," Mike Dudas says. He tries to get back every year. "It's always changing, it's always dynamic, and people always want to know about it."

For Dudas and many of today's *Andrea Doria* divers, the fact that the wreck keeps changing is part of her draw. Each collapsed section and rusted hull plate reveals tantalizing possibilities.

But each year, she gets a little further away from the glorious ship she once was. Nothing lasts forever in the harsh conditions of the North Atlantic, and someday soon, the ocean will reclaim the bones of the *Andrea Doria*. And when the scraps of her hull are buried in the sand, the ship's legacy will be found in a thousand artifacts scattered across homes and dive shops and museums—and in the stories of the divers who dared to reach her. PM

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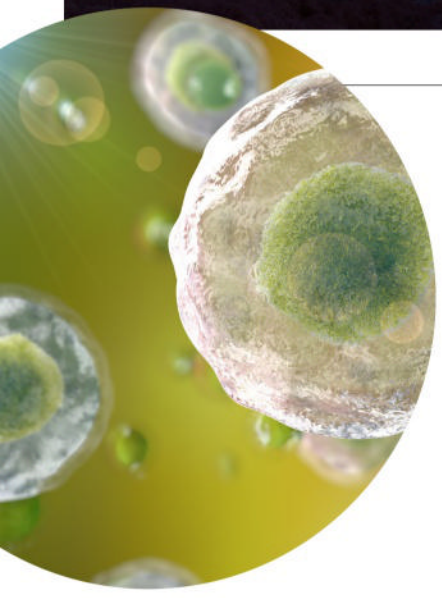

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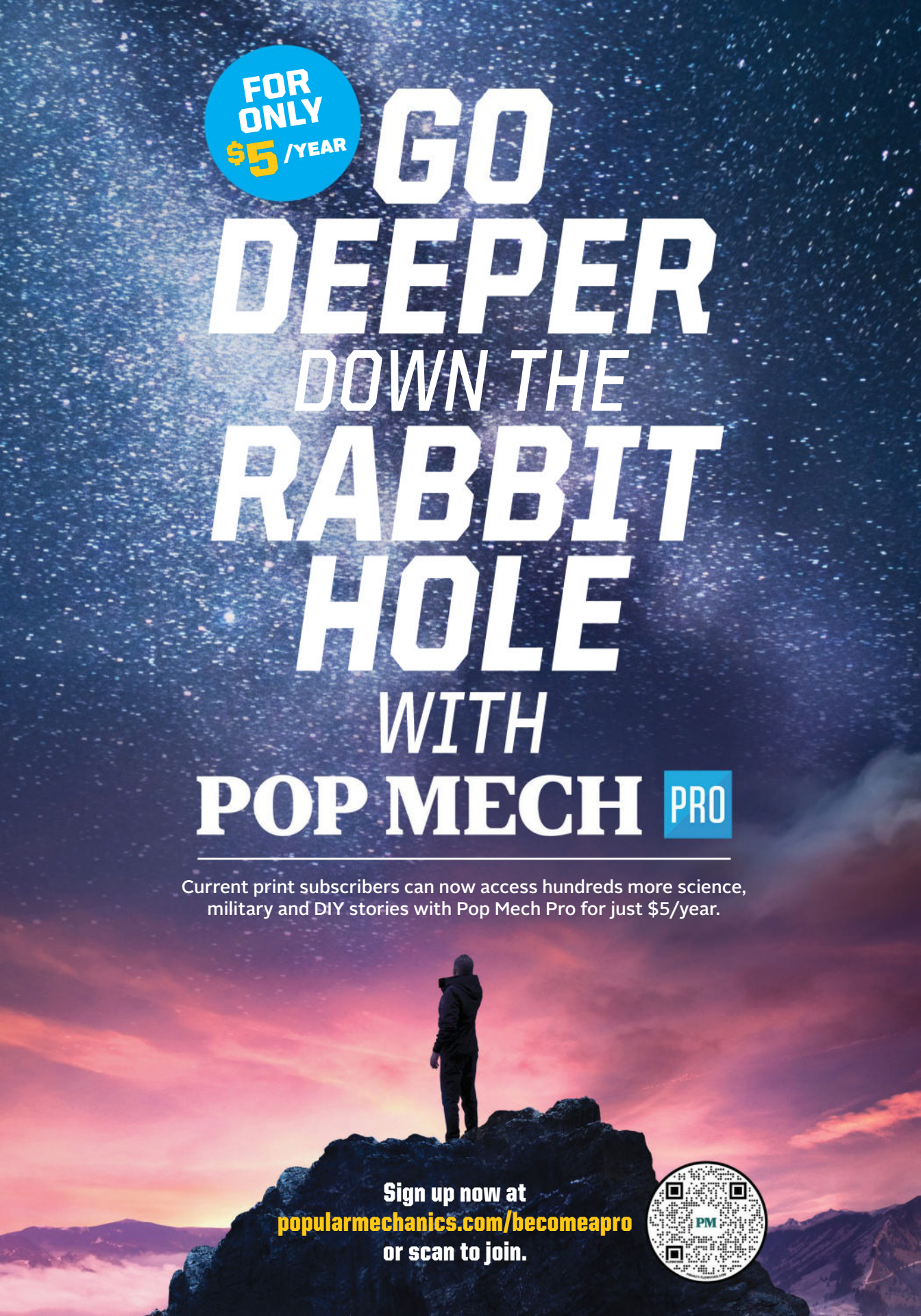
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