

Rotterdam: From Tiny Village to Europe's Greatest Port

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September/October 2016

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CONTENTS



26 An Italian archaeologist removes volcanic debris in an ancient Roman villa underneath the town square of Positano, Italy.

features

26 Romans on the Bay of Naples

A spectacular villa under Positano sees the light

BY MARCO MEROLA

32 Royal Sherwood

A long-overlooked site, the excesses of English royalty, and the origin of a legend

BY KATE RAVILIOUS

38 Worlds Within Us

Pulled from an unlikely source, ancient microbial DNA represents a new frontier in the study of the past—and modern health

BY SAMIR S. PATEL

44 A Splendid Failure

The wreck of CSS Georgia, a unique Civil War relic, emerges from Savannah's harbor

BY MARION BLACKBURN

50 A New View of the Birthplace of the Olympics

Taking an innovative approach to one of ancient architecture's most intriguing questions

BY JARRETT A. LOBELL

COVER: Stunning frescoes and molded plaster figures cover the walls of a newly re-excavated Roman seaside villa in Positano, Italy.

PHOTO: MARCO MEROLA

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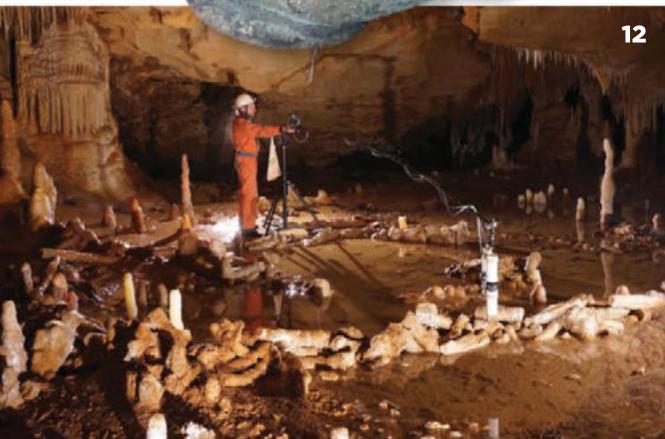
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on the web

■ More from the Issue To see more images of the Roman villa in Positano, go to archaeology.org/positano, and to view more reconstructions of the temple at Olympia, go to archaeology.org/olympia.

■ Interactive Digs Read about the latest discoveries at Zominthos in central Crete, Johnson's Island in Ohio, and Ireland's Achill Island at interactivedigs.com.

departments

4 Editor's Letter

6 From the President

8 Letters

Inside Scythian rituals, a Roman legion's fate, and the last voyage of a Phoenician priest?

9 From the Trenches

Rome's lost map, Neanderthal architects, new discoveries at Petra, the saga of a Viking siege, and unmasking Pan

24 World Roundup

Kennewick Man's roots, rise of the Wari Empire, turtle soup, hyenas vs. humans, and an ancient Chinese beer recipe

55 Letter from Rotterdam

How a small Dutch village became Europe's greatest port

BY HEATHER TUCKER

68 Artifact

Where Anglo-Saxons kept their mementos

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Roman Holiday

This issue's feature, "Romans on the Bay of Naples" (page 26), provides us not only with our cover, but offers more wonderful photos and engaging text by ARCHAEOLOGY's Naples correspondent, Marco Merola, about a sumptuous seaside villa on the Amalfi Coast. The eruption of Mount Vesuvius in A.D. 79 buried a number of these villas, including this one and its extraordinary frescoes, which are now being restored some 30 feet below the town of Positano.



Roman fresco

As the Games of the XXXI Olympiad come to a close, you'll be ready for "A New View of the Birthplace of the Olympics" (page 50), by executive editor Jarrett A. Lobell. Here, Lobell covers the innovative work of archaeologist Phil Sapirstein at the Temple of Hera at Olympia. Few of the building's columns, erected around 600 B.C., remain standing, but by using photogrammetry and 3-D modeling software, Sapirstein has

been able to develop a highly accurate virtual reconstruction of the temple, likely the first monumental building ever constructed at the site.

Myriad life forms, invisible to the naked eye, make their homes both in us and on us, and compose what is termed the human microbiome. These microbes are the subject of "Worlds Within Us" (page 38), by deputy editor Samir S. Patel. In it, Patel reports on cutting-edge, multidisciplinary research going on at an advanced ancient DNA lab at the University of Oklahoma. There, researchers are charting archaeology's next frontier as they investigate the microbiome's role across thousands of years of human history, and how our future may be inextricably linked with it.

"Royal Sherwood" (page 32), by journalist Kate Ravilious, details the study, in fabled Sherwood Forest, of the King's Houses, an enormous palace enclosure used by Britain's monarchs for centuries for both pleasure and diplomacy. Its story is also one of appropriation of the area's bounteous landscape to provision the royal table, which caused bitter hardship for the surrounding populace—and may have given rise to the legend of Robin Hood.

The Civil War and the introduction of ironclad warships changed naval battles forever. "A Splendid Failure" (page 44), by journalist Marion Blackburn, brings us the story of CSS *Georgia*, cobbled together by the Confederacy in the early 1860s out of whatever could be found as the Union blockade of Savannah's harbor choked off supplies. An engineering disaster, it was scuttled by Confederate forces to prevent its capture. Recently, U.S. Army Corps of Engineers researchers and archaeologists raised significant portions of *Georgia* and its considerable collection of artifacts in one of the biggest maritime excavations ever conducted in American waters.

And don't miss "Letter from Rotterdam" (page 55), by journalist Heather Tucker, which outlines archaeologists' work to uncover nearly 1,000 years of the city's history as it developed into Europe's most significant port.

Claudia Valentino
Editor in Chief

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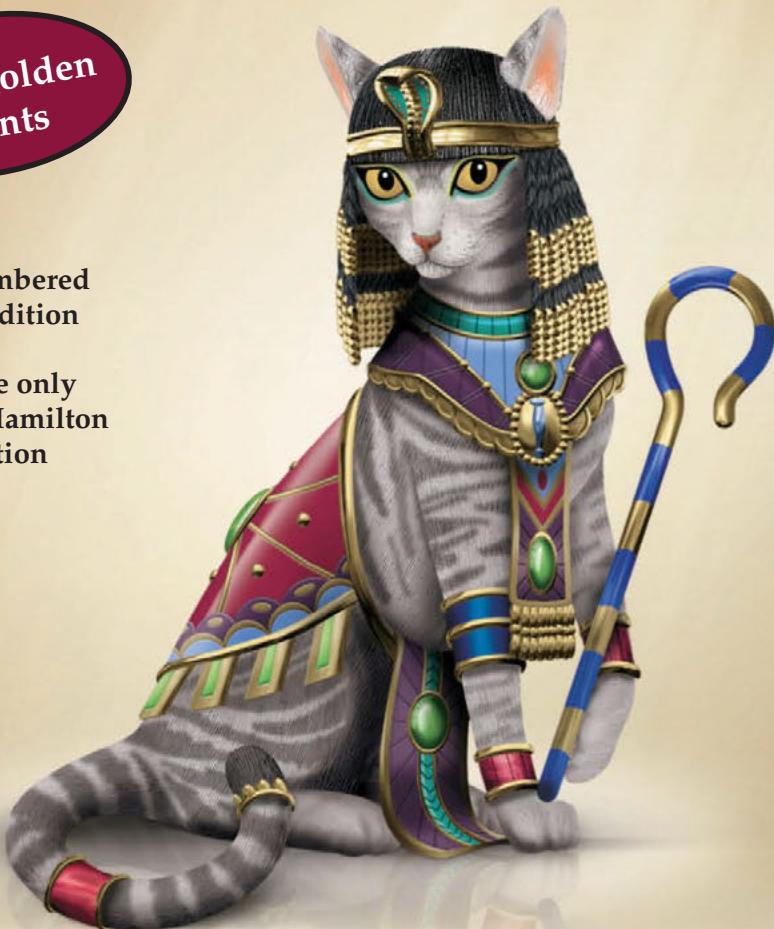
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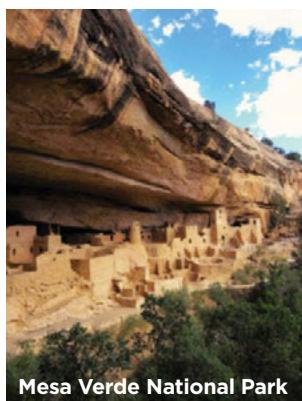
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Celebrations

This year we celebrate two important anniversaries in American archaeology: the centenary of the founding of the National Park Service, and the half-century of heritage conservation that has followed the passage of the National Historic Preservation Act. Both represent key efforts to preserve the best of the past for future generations.

Everyone knows that the National Park Service is the custodian of iconic wild places: Yosemite, the Grand Canyon, Yellowstone, and other awe-inspiring natural wonders. Fewer people are aware that the Park Service also cares for 40 major archaeological sites. Most of these are classified as national monuments. One of the first such sites to be preserved was Casa Grande Ruins in Arizona. Others include Bandelier and Aztec Ruins in New Mexico.



Mesa Verde National Park

Mesa Verde is one of the few archaeological sites designated a national park. This park contains 600 cliff dwellings, in addition to the famous Cliff Palace, in a setting of great natural beauty in southwestern Colorado. Exploration of Mammoth Cave in Kentucky over many years has yielded impressive testimony of Native American activity. The Park Service preserves several effigy mounds in Iowa and other important mound sites at the Hopewell Culture National Historical Park in Ohio. Among the most poignant sites of archaeological significance are the battlefields dating from the Civil War: Antietam in Maryland, Vicksburg in Mississippi, Shiloh in Tennessee, Manassas, Petersburg, and Richmond in Virginia, and several others. The Park Service remit even extends underwater to include the preservation of shipwrecks at the Point Reyes National Seashore in California and the Dry Tortugas National Park in Florida.

The archaeological work of the Park Service goes well beyond preserving sites for the future. Over the years staff members have engaged in extensive research at hundreds of archaeological sites in parks across the nation. Conducted to the highest professional standards, these investigations have illuminated the past 10,000 years of human history in North America. The artifacts recovered are curated and often exhibited in museums and other repositories within each park.

The National Historic Preservation Act established the National Register of Historic Places and provided grants to conserve them for public benefit. This has ensured the future of special places as diverse as the African Burial Ground in New York and the Confederate submarine *H.L. Hunley*. The act succeeded in establishing a historic preservation ethic in the public mind. The AIA is proud to be an official sponsor of the commemorations taking place this year.

These two anniversaries signify American respect for human accomplishment on this continent. They also testify to the importance of archaeology as part of our national heritage.

Andrew Moore

President, Archaeological Institute of America

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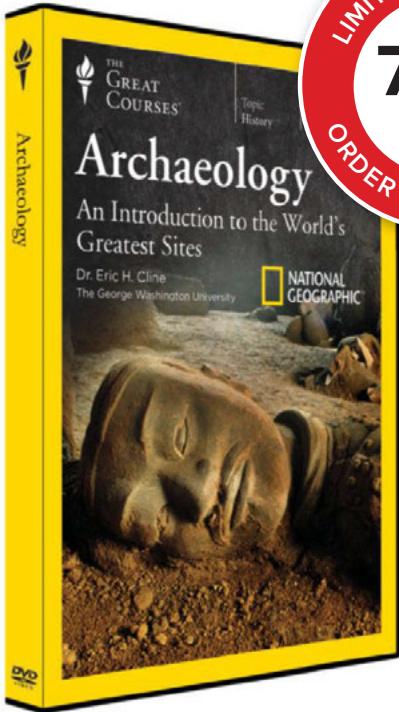
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Suggestions for the Scythians

I was so pleased to receive my July/August 2016 issue today with the article on the most recent dig of Scythian artifacts ("Rites of the Scythians"). I noticed in looking at the large vessel with the griffins attacking the stag that the garland trim around the top edge resembles mistletoe, *Viscum album abietis* or possibly *album*, which has leaves in opposite pairs, leathery textured, with white berries. What gives it away is the tied bow on the stem. The tree is bare. It is winter. Mistletoe had a sacred significance to the pagan world (which carried over into Christianity and Christmas traditions). I believe the picture symbolizes the dying of the old year and/or the dying of the sun.

Michel Bernstein
Los Angeles, CA

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I loved reading your article "Rites of the Scythians." The level of detail on the gold items was astonishing, and your photos of the works from many angles really helped show how the pieces would appear and fit together in their original context. The article states that "most kurgans are clearly tombs" and that empty ones "were rarely reported or written about in the past." Based on this "typical use" information, couldn't the Sengileevskoe-2 kurgan still have been a tomb as opposed to a human sacrifice, and the bones found in the stone box were all that were available from the decedent for burial? Since the Scythians were nomadic, maybe the person died far from the desired burial site and the entire body couldn't be transported; or maybe the death was in battle and these bones were all that could be recovered? Keep up the great work! I really enjoy how your magazine's format presents the finds, and also provides enthralling backstories and historical information to accompany the artifacts.

Rick Tamagno
Hamilton, NJ

While reading "Rites of the Scythians," I noticed that the vessels appear as if they might work similarly to incense diffusers. If the cups in which the hemp seeds are heated were turned over, this would allow smoke to stream through the hole that is now at the top. It would also be convenient for inhaling the smoke by placing one's head directly over the stream.

Daniel T. Westcott
Old Town, ME

A Priest's Possessions

The fascinating story of the Phoenician shipwreck by Jason Urbanus ("Masters of the Ancient Mediterranean," May/June 2016) includes the investigators' hypothesis regarding the odd assortment of cargo. I believe that, rather than trade goods, the "single, complete set" of furnishings likely represent the personal belongings of a high-ranking passenger, possibly a priest. That is reinforced by the presence of the temple goods. Rather than having been looted to be sold, perhaps they were intended to furnish a new temple.

R.J. Connors
Lake Wales, FL

The Wrath of the General

The skeletons at York described in "Off with their Heads" (July/August 2016) may have been Roman soldiers who suffered decimation, for which the Latin is *decimatio*. Whenever a Roman legion or maniple showed cowardice in battle, its commander could order one in every 10 men, who were chosen by lot, to be executed. Archaeologist Jon Coulston is correct, the beheading of gladiators and criminals was not a Roman practice. However, the beheading of Roman citizens did take place; as a matter of fact, only Roman citizens were beheaded. Since all of the men found at York were beheaded and since the emperor Caracalla gave all the peoples of the Roman Empire citizenship—except slaves—in A.D. 212, it seems very likely that these soldiers were beheaded after that date.

Clyde E. Billington
Niceville, FL



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From the Trenches

LATE-BREAKING NEWS AND NOTES FROM THE WORLD OF ARCHAEOLOGY

Piecing Together a Plan of Ancient Rome

For the past several hundred years, historians and archaeologists have been doggedly working to solve one of the world's largest jigsaw puzzles: the *Forma Urbis Romae*. Sometimes known as the Severan Marble Plan, the *Forma* was an enormous marble map of ancient Rome created between the years A.D. 203 and 211. Beginning in the fifth century, as the map fell into disuse, it was broken up into thousands of pieces, which were subsequently scattered throughout the city. Scholars have been retrieving the map's fragments from locations around Rome and attempting to determine their original positions for the past 500 years. Reassembling the map is slow, painstaking work, further complicated by the fact that thousands of fragments are still missing. However, authorities from the Capitoline and Vatican museums in Rome recently announced the discovery and identification of an important new section of the map, perhaps offering new insights into the topography of the ancient city.

The *Forma Urbis Romae* was created under the reign of the emperor Septimius Severus (r. A.D. 193–211). Measuring 60 feet by 43 feet, the map was incised onto 150 marble blocks arranged in 11 rows, and represented an area of over five square miles at a scale of 1:240. An incredibly detailed plan of Rome, it reproduced every building, house, shop, and monument in the smallest detail, even including staircases. The Marble Plan was originally on display in a room in the Temple of Peace in the Imperial Fora. The wall where the map was hung survives today as part of a complex of buildings belonging to the Church of Saints Cosmas and Damian. A series of holes in the wall reveals where the individual marble slabs were attached with

metal clamps. The *Marble Plan* was dismantled throughout the Middle Ages, and large chunks of it were reused in building projects throughout the city. Although around 1,200 fragments have been salvaged to date, experts estimate that only 10 to 15 percent of the original work survives. According



Fragments of the *Forma Urbis Romae*



Saints Cosmas and Damian Church complex, Rome, Italy

to Stanford University professor Jennifer Trimble, even though the Marble Plan is only partially reconstructed, it provides scholars with new and unique information concerning the layout and organization of ancient Rome. "The Plan itself is vitally important because it is our only source for the urban fabric of Rome," she says. "Standing ruins of major monuments and keyhole excavations

throughout the city have given us individual details, but the modern city overlies the ancient remains and makes it impossible to see how different kinds of spaces and buildings worked together, or what particular streets and neighborhoods were like."

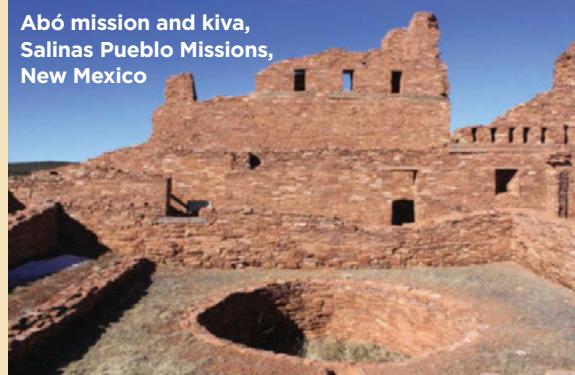
The newest fragment of the *Forma Urbis Romae* was discovered during construction work on the Palazzo Maffei Marescotti, which is owned by the Vatican. The piece corresponds to an area west of the Roman Forum known in modern times as the Ghetto. Researchers were able to pinpoint where it belongs on the overall plan because the new marble pieces contain parts of the Theater of Marcellus and the Circus Flaminus, monuments

known to have been located in that neighborhood. Not much archaeological evidence of the Circus Flaminus survives, so the fragment will help experts better understand its layout and function. Because of the *Forma Urbis Romae*'s resemblance to Roman cadastral plans, which are property surveys, some scholars believe that it may have been used for administrative purposes by the urban prefects. However, others suggest that it may have simply been an elaborate decorative showpiece. "The best explanation," says Trimble, "is that it was created as a spectacular monument that showcased the imperial city and detailed cartographic knowledge about it."

—JASON URBANUS

OFF THE GRID

In 1620, Spanish Franciscan missionaries arrived in what is now known as the Salinas area of New Mexico, southeast of Albuquerque, then a Native American community and trading hub populated by the Tompico and Tiwa Pueblo Indians. It is easy to see why the site appealed to the Spanish—both missionaries and traders—as the trade conducted there provided access to the Plains peoples, such as Apaches, and valuable bison hides. Spanish dreams of wealth in Salinas never materialized, and in the face of tribal conflict, drought, and famine, the pueblo and missions were abandoned in the 1670s. The spectacular ruins that remain today are an interesting combination of traditional Native American pueblos and Spanish mission architecture. According to Jake



Abó mission and kiva,
Salinas Pueblo Missions,
New Mexico

Ivey, a historian of Spanish architecture and former National Park Service archaeologist, they remain little visited, despite being designated a National Monument in 1909. The site has been expanded several times since.

The site

The Salinas Pueblo Missions National Monument consists of the ruins of three pueblos and two missions, divided among three locations—Quarai, Abó, and Gran Quivira—separated by miles of grassland. The northernmost site, Quarai, consists of a sizable red-orange sandstone church that stands about 40 feet tall. Pueblo mounds suggest that there was a significant Native American population there prior to Spanish contact. The mission also contains an unusual square

kiva, or subterranean ritual room, which might have been built by the missionaries to aid in conversion. A similar, though more traditionally round, kiva is also found in the church at Abó, 12 miles to the south. The largest and most remote of the three sites is Gran Quivira, originally known as Las Humanas, which includes the remains of

seven kivas, a 200-room pueblo, and two missions: an early one used for years, and the larger but unfinished Mission San Buenaventura, with walls up to 30 feet high. Unlike the warm sandstone of the other sites, Gran Quivira is built from large, angular, gray limestone chunks. All three sites are served by a centrally located visitor center in the town of Mountainair.



Gran Quivira pueblo

While you're there

The ruins are accessible as a day trip from either Albuquerque's chile-inflected New Mexican cuisine or Santa Fe's wealth of galleries and shops. Outside Albuquerque is Petroglyph National Monument, home to an estimated 24,000 images carved into dark volcanic rock. And nature lovers should visit the Sevilleta National Wildlife Refuge, which includes steppe, prairie, desert, and woodland environments, with the Rio Grande flowing right through the middle.

—MALIN GRUNBERG BANYASZ

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Gimme Middle Paleolithic Shelter

In 1990, cavers in southwestern France reopened a cave that had long ago been closed off by a landslide. More than 350 yards inside the feature, which they named Bruniquel, they found strange constructions made from broken stalagmites. A new study of these structures shows they were built 176,000 years ago, a time when Neanderthals were the only hominins living in Europe. That places these among the oldest structures made by humans anywhere in the world, and the only known surviving ones made by Neanderthals. In the

cave, stalagmite fragments were arranged into six structures, some vaguely oval-shaped and others more like free-standing walls. Each of them had been charred by fire. This is also the first evidence of Neanderthals living (or at least spending a lot of time) deep inside a cave, though they often lived near cave entrances. According to the researchers who studied the formations, the Neanderthals who lived at Bruniquel appear to have been more socially organized than others.

—ZACH ZORICH



Bruniquel Cave, France

Zapotec Power Rites

As early as 700 B.C., the Zapotec people of Mexico's Oaxaca Valley were ruled by lords living in the city of Monte Albán who practiced public rituals that reinforced their vast power. But around A.D. 700, Monte Albán's influence began to wane. Now archaeologists excavating at a wealthy residence at the site of Dainzú-Macuilxochitl have found evidence that, around that time, Zapotec nobles were practicing private rituals that celebrated their personal power. A

team led by Field Museum archaeologist Ronald Faulseit unearthed a temple connected to a noble residence where they found two pierced human mandibles, one of them carved. The bones likely belonged to venerated ancestors and were worn as adornments during rituals that focused on the importance of hereditary power. "They were stressing their own noble lineage," says Faulseit, "and emphasizing their political and economic independence."

—ERIC A. POWELL

Carved human mandible



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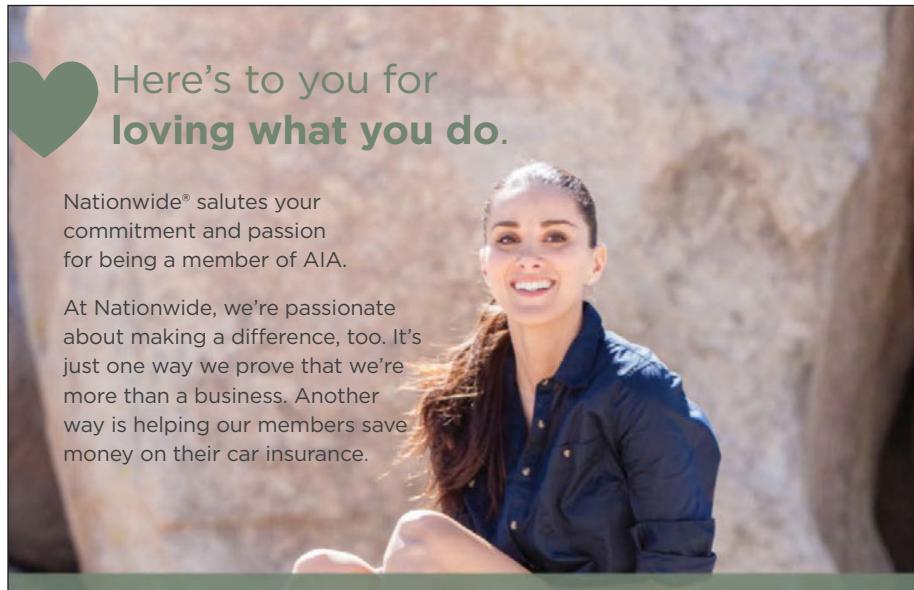
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Mystery Buildings at Petra

Satellite imagery and aerial photography have revealed several previously undocumented structures a little more than a mile southwest of Petra in Jordan, a major center of the Nabataean culture, famous for its elaborately decorated buildings carved into pink sandstone cliffs. The new sur-

Newly discovered platform, Petra, Jordan



vey, conducted by Sarah Parcak of the University of Alabama at Birmingham and Chris Tuttle of the Council of American Overseas Research Centers, shows clusters of previously unknown archaeological features, including remnants of two buildings and a trench that was dug by archaeologists in 1929 but whose location had been forgotten. Perhaps the most significant discovery is a 184-by-161-foot platform with a 28-foot-square building foundation atop it. Pottery sherds found there indicate that it was built before the second century B.C. Strangely, the platform is not in a place easily accessible from Petra's city center. How it might have been used is a mystery.

—ZACH ZORICH

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Sun and Moon



Treasures from the Roman era have emerged from the waters of the ancient Mediterranean harbor of Caesarea in Israel—the largest underwater find in the country in 30 years. The spectacular discovery includes



a bronze lamp depicting the sun god Sol, a figurine of the moon goddess Luna, a lamp in the shape of the head of an African slave, fragments of three life-size bronze statues, and a figurine of the god of wine, Dionysus. The archaeologists also recovered two metallic lumps composed of thousands of coins bearing the images of the Roman emperors Constantine and Licinius, and holding the shape of the pottery vessels that once enclosed them. According to Jacob Sharvit, director of the Marine Archaeology Unit of the Israel Antiquities Authority, the cargo comes from what was probably a large merchant ship that sank around 1,600 years ago, and may have been slated to be recycled had the ship reached port. "The cargo gives us some important clues on commerce at that time," he says. "We can date it to a short time after Constantine the Great won the battle against Diocletian, and made economic changes and declared Christianity the religion of the empire."

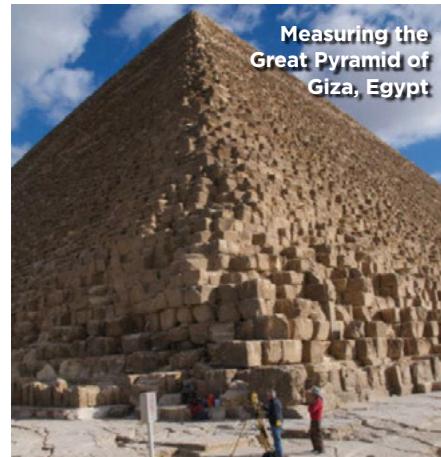
—ROSSELLA LORENZI

The Great Parallelogram

A new survey of the dimensions and orientation of ancient Egypt's Great Pyramid of Giza has found that its builders attained a remarkable degree of accuracy despite limited technology. The 4,500-year-old pyramid is laid out with its sides running just one-fifteenth of a degree askew of the cardinal directions. In addition, each side of the pyramid's original base measured around 756 feet long, but with the west side measuring about 2.9 inches longer than the east side, and the south side about 2.2 inches longer than the north side.

Estimating the pyramid's initial dimensions is challenging given that it was originally clad in casing stones, almost all of which were repurposed as building materials several hundred years ago. Along the structure's 3,000-plus-foot perimeter, only 177 feet of casing stones remain. To provide additional data, archaeologist Mark Lehner, director of Ancient Egypt Research Associates, looked for etched or cut lines at the pyramid's base to indicate the location of its original edges. He found 84 such points, most of which are near the centers of the sides, with no evidence of the original corners remaining.

Glen Dash, an engineer and head of the Glen Dash Research Foundation, and his team used a statistical method known as linear regression analysis to estimate the full extent of the pyramid's edges based



on Lehner's data points, resulting in the finding that the base is not quite square. "It is slightly a parallelogram," says Dash, and this suggests its builders were better at measuring precise distances than they were at measuring precise right angles.

"We think they were simply using wood, rope, copper, and stone, and were

still able to achieve this level of precision," says Dash. These margins of error, he says, are similar to what one would find in most modern-day construction projects, although structures such as bridges and high rises are held to more exacting standards.

—DANIEL WEISS

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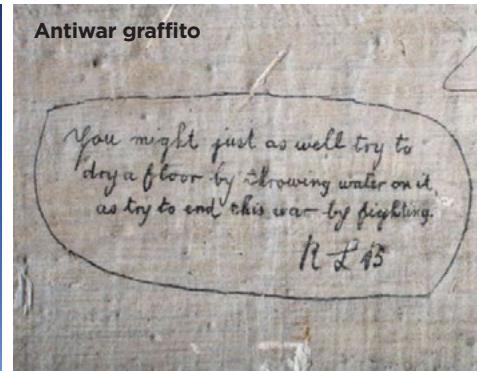
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The Prisoners of Richmond Castle

A new grant provided by England's Heritage Lottery Fund will help preserve and document graffiti drawn by prisoners in North Yorkshire's Richmond Castle during World War I. The imprisoned men were conscientious objectors who refused to serve in the British Army. In 1916, the British government passed the Military Service Act, which conscripted all unmarried men aged 18 to 41 into military service. The law stipulated that those who refused to enlist due to a conscientious objection could avoid combat, as long as they served within the Non-Combatant Corps. However, a small "absolutist" group of Methodists, Quakers, and socialists refused to participate in the war effort in any capacity, and were subsequently jailed in Richmond Castle. Known as the Richmond 16, these prisoners covered the walls of their cells with thousands of pencil-drawn images, political slogans, biblical quotes, and religious hymns. One statement reads, "You might just as well try to dry a floor by throwing water on it, as try to end this war by fighting." Another states, "The working class of this country have no quarrel with the work-



Richmond Castle, England



Antiwar graffiti



Sketch of "Kathleen"

ing class of Germany or any other country."

After 100 years, the limewash and plaster walls have been heavily damaged by moisture, threatening the survival of the graffiti. "These graffiti are an important record of the voices of dissent during the First World War," says Kate Mavor, English Heritage's chief executive. "Now we can ensure that they survive for the next century and that the stories they tell are not lost."

—JASON URBANUS

A True Viking Saga

Askeleton found at the bottom of an abandoned well in Trondheim, Norway, seems to confirm a tale of defeat and destruction told in an ancient Norse saga. In 1197, a faction of the Norwegian aristocracy known as the Baglers attacked Sverresborg, the castle stronghold of the Viking king Sverre. The story of the siege—including the "killing" of the castle's well by throwing the dead body of one of the king's men into it—is well known, but its veracity has been questioned. "Sverre's

saga has very detailed descriptions of the battles between the king and his main enemy, and it's also rich in references to places and people," says lead archaeologist Anna Petersén of the Norwegian Institute for Cultural Heritage Research. "The human remains in the well indicate that the saga is trustworthy. The proven relationship to events described in Norwegian history makes this discovery unique, and a once-in-a-lifetime opportunity."

—JARRETT A. LOBELL



Well excavation, Trondheim, Norway

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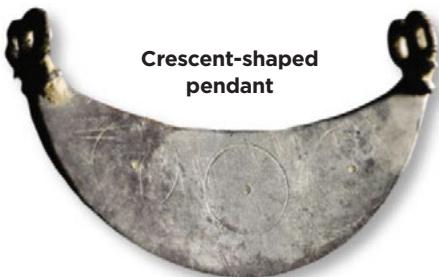
In northeastern France's Alsace region, a team from the National Institute for Preventive Archaeological Research has discovered graphic evidence for a violent Neolithic-era clash of cultures. While digging in a fortified village dating to between 4400 and 4200 B.C., archaeologists unearthed a storage pit that held the mutilated remains of five men and one teenage boy, as well as four severed left arms. Archaeologist Philippe Lefranc suggests the limbs were battlefield trophies, and that the skeletons belonged to members of a captured enemy war party. "I think we are seeing ritualized violence against captives who were initially alive," says Lefranc. "It probably took place in the middle of the village during a victory celebration. All the remains were eventually thrown in a ritual refuse dump." Lefranc thinks the enemy warriors were from a new population migrating into the area from the Paris Basin to the west. Despite losing this round, they eventually triumphed. At the end of the fifth millennium, the local pottery style and burial rituals



were replaced by those of the newcomers, and all the old villages in Alsace were relocated.

—ERIC A. POWELL

Lost and Found (Again)



Crescent-shaped pendant



Hacksilver (buckle wrapped over coin)

Silver ingot

In 1838, a cache of silver was found at Ley Farm in Aberdeenshire in northeast Scotland. While what came to be known as the Gaulcross Hoard might have originally contained more artifacts, only three pieces are known today from the original discovery. Almost 200 years later, archaeologists have gone back to the site and unearthed no less than 100 new silver artifacts from the hoard, including ingots, a crescent-shaped pendant, and a zoomorphic brooch, along with other jewelry fragments.

Some of the most interesting objects are what is termed hacksilver—plates, spoons, belt fittings, bracelets, and even

coins that were deliberately broken, cut, or bent before being used as currency or melted down for reuse. "Our work is the first to acknowledge the existence of hacksilver extending beyond the Roman period and into the fifth and sixth centuries A.D. in Scotland," says Alice Blackwell, who is studying the hoard as part of the National Museum of Scotland's Glenmorangie Research Project. "It has long been apparent that silver was the main material used in early medieval Scotland to show wealth and power, but what we have lacked until now is any real understanding of how this most precious resource was managed."

—JARRETT A. LOBELL

The City That Wasn't

Formations discovered in shallow water off the coast of the island of Zakynthos in the Ionian Sea were initially thought to be the remains of an ancient Greek city. However, there is a puzzling absence of artifacts such as ceramic sherds among what appear to be columns and paving stones to indicate that people had ever actually lived there. Now researchers have subjected these "structures" to a range of tests, and found that they are indeed extremely old, but they certainly weren't made by the ancient Greeks.



Dolomite "column"



Dolomite "paving stones"

"The first few photographs I saw really did look as if they might be columns and paving slabs," says Julian Andrews, an environmental scientist at the University of East Anglia, "but as I saw more images, it was clear they probably weren't."

Based on carbon isotope analysis of a sample of the formations, Andrews and his colleagues determined that they were formed by microbes that use hydrocarbons seeping through the seafloor, most likely methane, as nour-

ishment. These bacteria lived around 16 feet below the seafloor at the time, in an oxygen-free environment. Their waste helped transform the sediment around the seeps into a natural cement-like substance known as dolomite. In the years since, the sediment eroded away, exposing the formations.

Analysis of strontium isotopes in the sample helped the researchers determine when they were created. "We can be reasonably confident they're no older than the Pliocene Epoch," says Andrews, "so they're probably no older than four million years."

—DANIEL WEISS

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Pan mask during (left) and after (right) cleaning and conservation



Mask Metamorphosis

Just as the details of a spectacular first- to third-century A.D. bronze mask have emerged after more than a year of conservation, so has the true nature of a newly excavated area of the important ancient city of Hippos-Sussita in Israel begun to take shape. The mask is almost 12 inches tall and 11 inches wide, and weighs more than 11 pounds. Because the artifact is unique—it is the only large bronze mask depicting the wild, rustic demigod Pan to have been found in Israel—conservators decided to clean half by hand, then assess it before continuing with the rest.

More recently, the Hippos-

Sussita team, led by Michael Eisenberg of the University of Haifa, has uncovered a large basalt *propylaeum*, or gateway, which he can now connect with the tower in which the

mask was found. “At first the mask seemed like it was almost a random find, having been discovered some 60 feet away from the complex we were digging in,” says Eisenberg, “but now I am starting to realize that it’s connected to that area and supports one of the leading assumptions we have—that we are actually excavating a sanctuary dedicated to the god Dionysus or to Pan, who was part of his retinue.”

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WORLD ROUNDUP



WASHINGTON: As far as the U.S. Army Corps of Engineers is concerned, the controversial saga of Kennewick Man is near its end. The 8,000-year-old skeletal remains found in the Columbia River in 1996 have been the subject of legal challenges since it was suggested, based on physical evidence, that they might not be Native American in origin. According to the latest research, the Corps has determined that Kennewick Man is indeed Native American, opening the door for his return to one of the tribes that claims a connection.



ANTIGUA AND BARBUDA: Life was difficult for the British sailors stationed in the Caribbean during the Napoleonic Wars. Many died from disease, and it is suspected many also fell victim to

heavy metal poisoning. Analysis of remains from the cemetery of the Royal Naval Hospital in Antigua revealed lead poisoning—in some cases severe enough to contribute to death. Potential sources of the toxic metal could be linings of water systems, medicines, and, perhaps most notably, rum distilled using lead coils.



THE NETHERLANDS: Outside of caviar, perhaps, only a very few delicacies come in cans. Construction workers at a railway tunnel site stumbled on the remains of just such a treat: a can of turtle soup dating to between 1860 and 1900. The dish has lost popularity in the West for various reasons—the taste, the fact that some are endangered species—but was once coveted enough to grace the tables of European royalty, possibly because turtles aren't native to northwestern Europe.



PERU: There are two basic means for an imperial power to impose its will: by replacing the original population or through diffusion of the imperial culture. To examine the rise of the Wari Empire (A.D. 600–1100) in the Andes, geneticists studied DNA from 34 burials at the Huaca Pucllana site dating to before, during, and after Wari rule. The results show only subtle changes in genetic diversity, suggesting that at this site, the Wari did not decimate the people of the Lima culture who already lived there.

MOROCCO: Early humans certainly competed with large carnivores for resources, including prey and the natural shelter of caves, but there is little direct evidence for their interaction before the Upper Paleolithic (roughly 50,000 to 10,000 years ago), when humans began hunting carnivores in numbers. A hominin bone belonging to the species *Homo rhodesiensis* and around 500,000 years old, found among a large deposit of bones in a cave in Casablanca, had been cracked, gnawed, and punctured—probably by an extinct hyena. The find shows how easily humans and large carnivores could change places on the food chain.





LITHUANIA:

Nazi killing site, beginning six months before Adolf Eichmann proposed the “Final Solution.” New remote sensing studies of the site have uncovered evidence of several massive burial pits, as well as a 100-foot-long tunnel, dug by spoon and hand, through which a dozen prisoners, who were being forced to exhume burial pits and burn evidence of the killings, managed to escape on the last day of Passover in 1944. Eleven survived the war to provide testimony of the atrocities.



GEORGIA:

In traditional Georgian banquets today, guests engage in elaborate toasts involving wine drunk from animal-horn vessels. Archaeologists at the site of Aradetis Orgora recently discovered a jar and two animal-shaped clay vessels, one containing pollen from the common grape vine. Belonging to the Kura-Araxes culture and dating to 5,000 years ago (and therefore probably not related to modern traditions), the jar might have been used to decant wine into the vessels for ritual consumption.

CHINA:

Broomcorn, millet, barley, Job’s tears, tubers—this ancient Chinese beer recipe probably produced an interesting bouquet. The ingredients were identified from residues found in a variety of clay vessels, including a funnel, that may have comprised a “beer-making toolkit” from a 5,000-year-old site in Shaanxi. The find is also the earliest known identification of barley in the country, suggesting the grain was introduced for beer production rather than as food.



MADAGASCAR:

This island nation is 300 miles from the coast of Africa and 3,700 miles from Southeast Asia, but the people there speak Malagasy, an Austronesian language related to Malay and Hawaiian. This suggests that the island was colonized around 1,200 years ago from across the Indian Ocean, but until now there was no physical evidence to back up the linguistic and genetic data. Recently excavated botanical remains have provided the first tangible link—the remains of Asian crops, including rice and cotton—at sites there and on the Comoros islands closer to the African mainland.

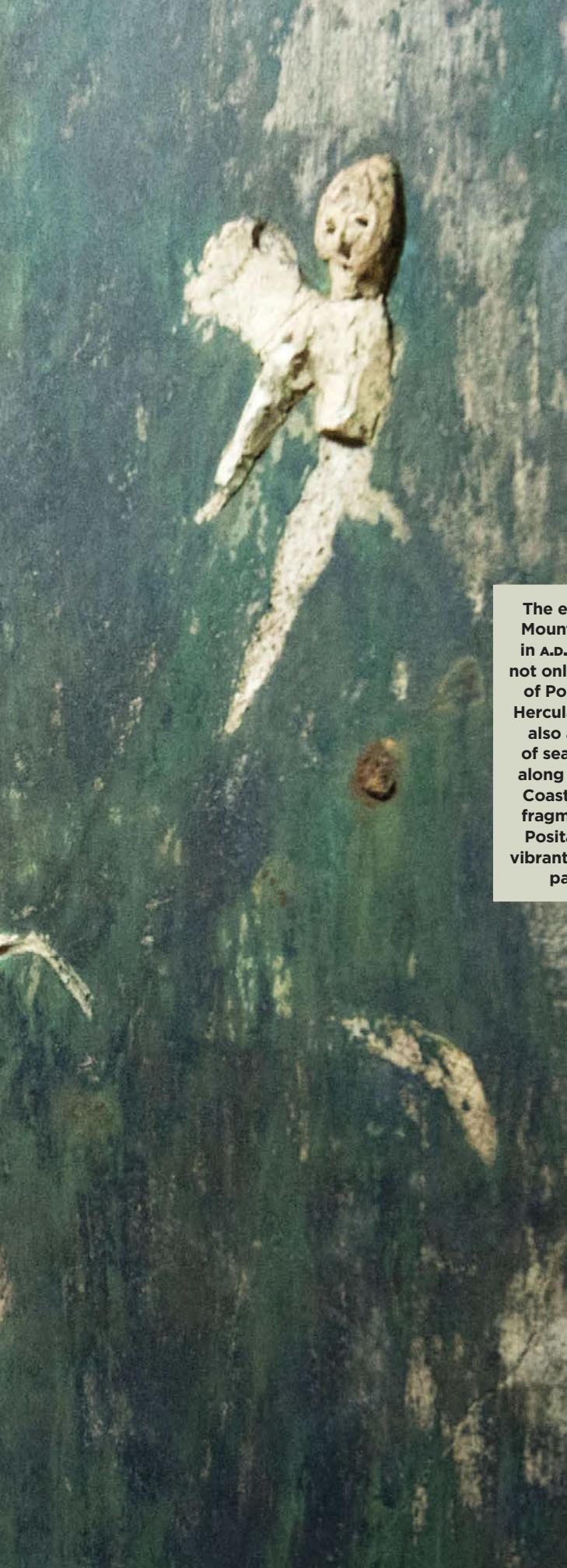


MALAYSIA:

The “Deep Skull,” found in 1958, is still the earliest known remnant of a modern human in island Southeast Asia, at 37,000 years old. It had been thought that the skull, from Borneo, came from someone related to indigenous Australians, and that the islands were settled in two waves—first by ancestors to Australians and then by immigrants from Asia who became Borneo’s modern indigenous people. A new analysis, however, found that the skull appears to be more Asian than Australian in origin, suggesting there was just one major migration.



Cupids riding sea monsters and dolphins, rendered in stucco, pull an elegant green drape on the frescoed wall of a newly re-excavated Roman villa in Positano. The use of figural stucco is rare in domestic contexts, appearing more commonly in public spaces such as baths.



ROMANS ON THE BAY OF NAPLES

A spectacular villa under
Positano sees the light

text and photographs by MARCO MEROLA

The eruption of Mount Vesuvius in A.D. 79 buried not only the towns of Pompeii and Herculaneum, but also a number of seaside villas along the Amalfi Coast. Below, a fragment of the Positano villa's vibrant fresco wall painting.

ONCE WE REACH the spot, you won't believe your eyes," says archaeologist Luciana Jacobelli of the University of Molise as she opens a small door to the crypt of the church of Santa Maria Assunta in the center of town. It's very dim inside, and she has to use a flashlight as we make our way. We slowly climb down a series of ladders through a forest of iron scaffolding toward what seems to be the only well-lit area, nearly 30 feet under the church. Jacobelli then leads me into a room and, as promised, frescoes in dazzling green, yellow, red, and blue seem to illuminate the space on their own. We have arrived at the extraordinarily well-preserved remains of a lavish *villa marittima*, or seaside villa, once a luxurious retreat for the rich of ancient Rome to escape the summer heat and the hustle and bustle of city life in the first centuries B.C. and A.D.





Archaeologists and conservators work 30 feet under Positano's town center to uncover and clean the walls of the *triclinium*, or dining room, which are completely covered in frescoes.



Mythological scenes, such as this one of cupids and the god Dionysus playing musical instruments, were popular subjects for fresco paintings that decorated the houses of well-to-do ancient Romans.

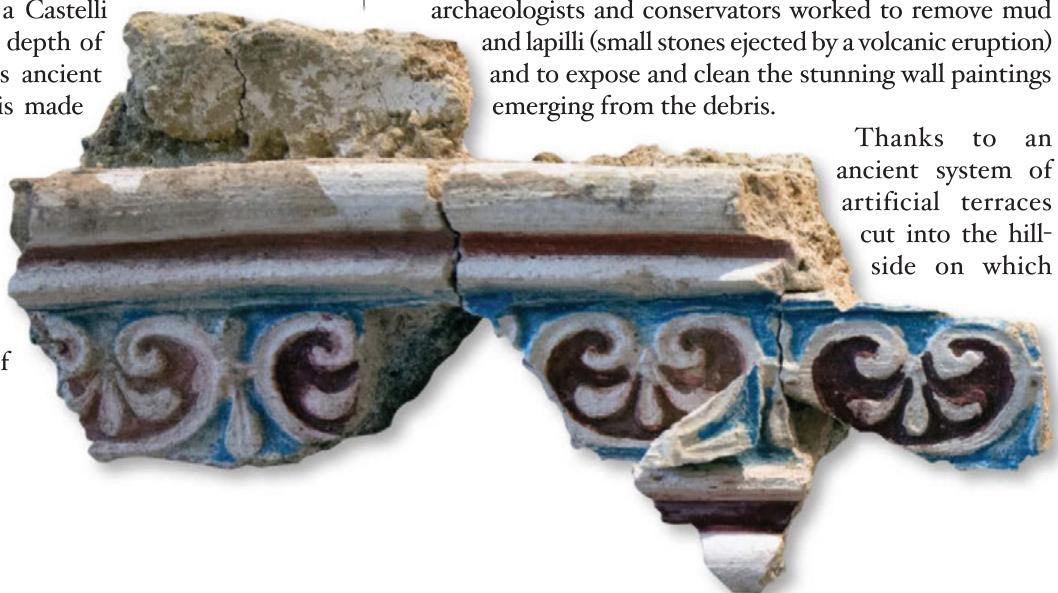
SWISS ARCHITECT AND engineer Karl Weber, the first scholar to supervise excavations of the areas destroyed by the eruption of Mount Vesuvius in A.D. 79, appears to have seen the villa on April 16, 1758, during his explorations. In his field report he writes that he had begun to dig near the “church with bell tower, not far from the beach that is at the base of Mount Santa Maria a Castelli and Mount Sant’Angelo; at a depth of 30 spans we found a famous ancient building whose first mosaic is made of white and fine marble.”

It was only during restoration work on the crypt in 2003 that archaeologists had a chance to enter the villa’s stunning *triclinium*, or dining room, for the first time. But after only three years of

In addition to painted walls, archaeologists have also found fragments of painted plaster that once decorated the *triclinium*’s moldings.

digging, they were forced to stop when funding ran out, and it wasn’t until the summer of 2015 that excavations resumed. For the rest of the year, before funding for the project ran out again, Jacobelli led a rescue excavation under the supervision of the local archaeological superintendent, Adele Campanelli, and archaeological supervisor Maria Antonietta Iannelli. A team of archaeologists and conservators worked to remove mud and lapilli (small stones ejected by a volcanic eruption) and to expose and clean the stunning wall paintings emerging from the debris.

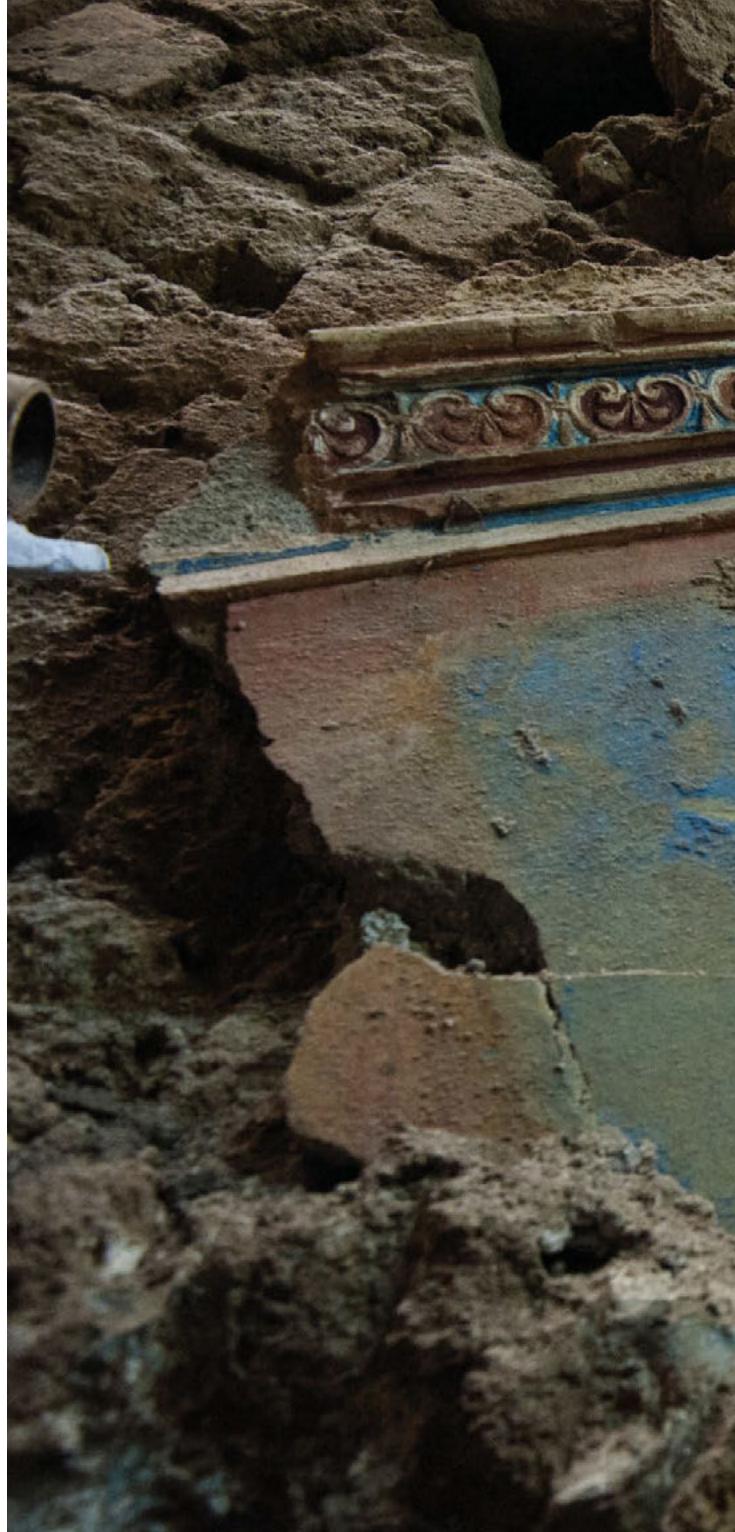
Thanks to an ancient system of artificial terraces cut into the hillside on which



An archaeologist perches on scaffolding in the *triclinium*. Some of the room's walls are preserved to their full height of nearly 18 feet, while others were toppled, likely by the force of the eruption of Vesuvius almost 40 miles away.



The villa's owner commissioned the finest artists to create expertly painted images of fantastical architecture (above) and the highest quality stuccowork (right).



Positano sits, the villa may have sprawled across more than 2.25 acres. Some scholars think that it might even have been as large as the town of Positano. Mantha Zarmakoupi of the University of Birmingham, an expert on the ancient Roman luxury villas of the Bay of Naples, disagrees. "I can imagine that the villa was perched on a terraced platform with ramps leading to other terraces below, and may have stretched over two or more levels in the hillside, as houses do today, but I don't think that it would have occupied the entire village," she says.

What isn't in doubt, however, is the excellence of the



frescoes covering the villa's walls. "The quality of the wall paintings is very high, and the triclinium's decorative program seems unique," says Zarmakoupi. "The combination of frescoes with stucco is rare and remarkable. The rendering of details in stucco, for example in the figures both holding and decorating the drapery, accentuates the feeling that the cloth is actually pliable."

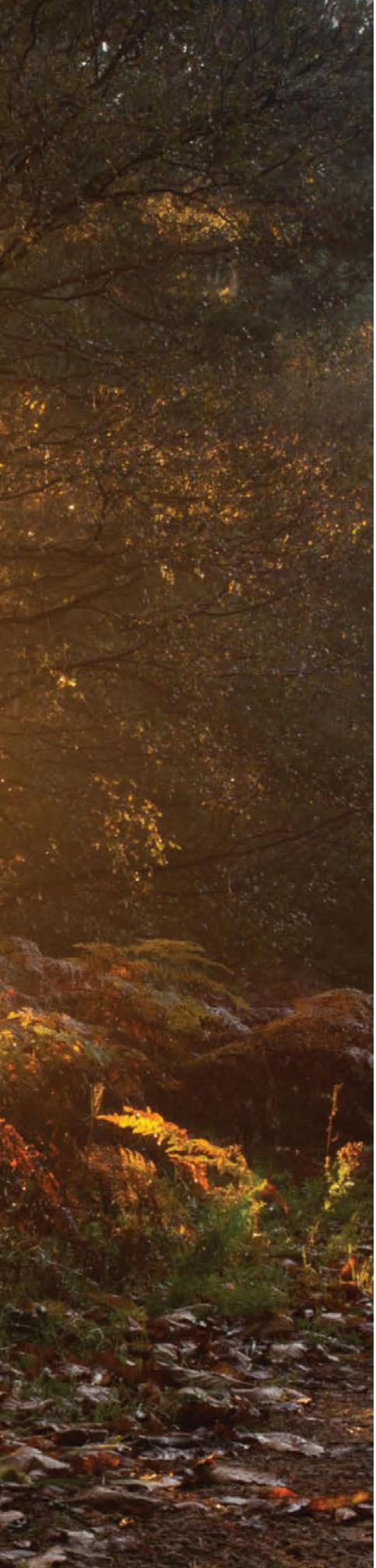
In addition to the magnificent paintings, in a hole opened in the layer of volcanic debris under the triclinium's northern wall, archaeologists unearthed a pile of oxidized jars, cups, and

dishes that formed a set of silver intended for a symposium—just the type of conversational gathering that would have taken place between the villa's owner and his important guests.

Local administrators hope to open the property to the public and are planning a transparent footbridge over the site. This will allow visitors to get a small taste of the luxe life as it was almost 2,000 years ago. ■

Marco Merola is ARCHAEOLOGY's Naples correspondent. For more stunning images of the villa, go to archaeology.org/positano.





In the early 14th century, the English crown claimed portions of Sherwood Forest (left) for private use, igniting discontent among peasants who relied on its resources. That unhappiness may have led to the creation of the Robin Hood legend.

A long-overlooked site, the excesses of English royalty, and the origin of a legend

by KATE RAVILIOUS

Royal Sherwood

The year, 1316. The location, Sherwood Forest, central England. According to historical records, a tenant farmer named Peter Witheberd was among the many who scratched out a meager existence there with small farm plots, some livestock, and whatever they could gather from the woods. Sherwood Forest was known as common land, and villagers relied on it as a place to graze pigs, collect firewood, and gather mushrooms and fruit. It's possible to speculate that, one day that year, as Witheberd picked up kindling near his modest home, the silence of the woodland was broken by the clatter of hooves. A group of richly clothed noblemen galloped through and ordered any villagers they saw off the land. It would now be part of King Edward's deer park, they claimed. Witheberd, or anyone else in the woods that day, had no choice but to trudge home with an empty basket. Over the coming weeks, villagers far and wide angrily discussed the King's high-handed behavior.

It was from this fraught social setting, a time of royal extravagance and popular discontent, that the story of Robin Hood—a heroic outlaw who robbed from the rich and gave to the poor—emerged. Historians are unsure if the folk hero was based on a real person or was invented by medieval balladeers, but the legend of his rakish nobility and outlaw persona has persisted ever since. Even if his origins are obscure, the history of conflict and animus between medieval villagers and royalty central to those tales is all too real. Previously overlooked ruins in Nottinghamshire are adding to the understanding of how England's medieval aristocracy indulged itself, how the social tensions of the time simmered, and how folk heroes transcend their origins to become legends.

Today, from the slope of a gentle hill, the village of Kings Clipstone provides a scenic view of the bowl-shaped landscape below. Pastures roll out from a ribbon of houses and, beyond, the famous trees of Sherwood Forest line the horizon. It can be hard to imagine that this slice of countryside was ever home to anything more than the bucolic rhythms of rural life. But just above the village, near the hill's peak, lie some unremarkable-looking ruins that tell a different story. Tumbledown stone walls emerge, up to two stories in some places, from a sea of well-tended grass. Weeds sprout here and there from the ruins, which enclose three sides of an area roughly the size of a tennis court. When archaeologist James Wright of Museum of London Archaeology first visited in 2004, he was an employee of the Nottinghamshire County Council conducting a survey of castles and other stone buildings. His initial thoughts centered on the site's survival. "I'd recently switched from being a stonemason to an archaeologist, and viewing the ruins through my stonemason's eyes gave me great concern," says Wright. "I could see daylight through the walls of the building and it was clearly in a shocking and very unstable condition."

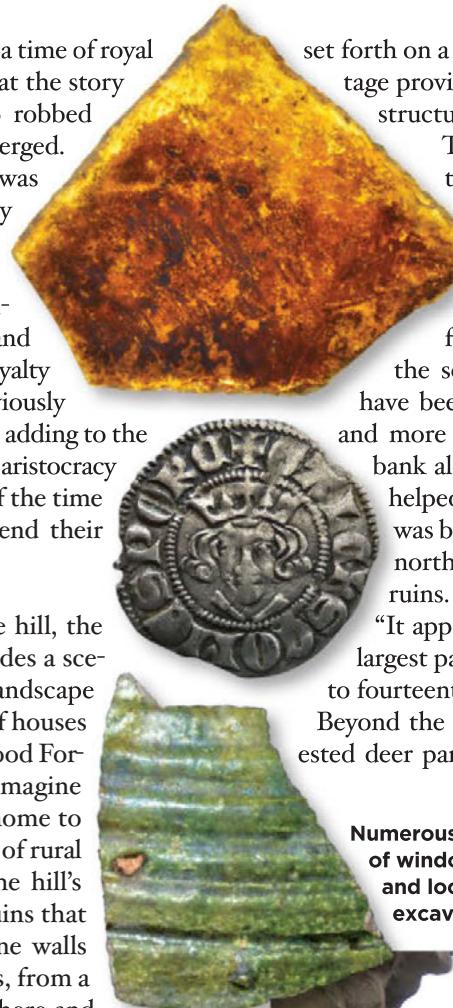
It had long been thought that the Clipstone ruins were an old royal hunting lodge, an interpretation put forth by local historian Alfred Stapleton in 1890. Archaeological excavations in the 1950s supported this idea, but more recent historical assessments have associated the site with a royal palace known as the "King's Houses." Whereas Stapleton had seen a modest, late thirteenth-century structure, it had become clear that the ruins belonged to a much more elaborate structure built up over centuries. "Coupled with the fact that it was in a shockingly poor state of repair, I was hooked," Wright says. "This was a nationally important monument that badly needed conservation work and research to fully reveal its true significance." Together with the landowners, Martin and Michelle Bradley, the Nottinghamshire County Council and English Heritage

set forth on a plan to conserve the site, with English Heritage providing funds for a stonemason to stabilize the structure in 2009.

Then in 2010, Andy Gaunt, also of the Nottinghamshire County Council, conducted a resistivity survey, which scans for changes in the makeup of the soil and revealed a wealth of anomalies around the ruins, including a linear feature more than 500 feet long that slices through the landscape to the southwest. Later excavation showed this to have been a substantial ditch, around 20 feet wide and more than three feet deep, with a 10-foot-wide bank along it. A map of the area from 1630 further helped the archaeologists delineate the site, which was bounded by a lake to the east and a road to the north, with a possible gatehouse northeast of the ruins. "Frankly, the site is enormous," says Wright. "It appears to cover 7.5 acres, making it one of the largest palace enclosures in Britain during the twelfth to fourteenth centuries."

Beyond the complex lay a huge expanse of private, forested deer park and a large glittering lake created in the

Numerous artifacts, including (top to bottom) a piece of window glass, a continental sterling of Florennes, and locally made pottery, have been uncovered in excavations (below) at the King's Houses.



1170s by damming the local stream, Vicar Water. Today only the earthworks of this lake are visible. “Documents say that this lake provided 100 pike and 1,600 roach for a feast during Edward II’s visit [to the King’s Houses] during the winter of 1315–1316,” says Gaunt, now director of Mercian Archaeological Services CIC, which has conducted surveys, field schools, and test excavations across the site for the last three years as part of the ongoing Sherwood Forest Archaeology Project. The prodigious production of the lake hints at the extravagance and scale of entertaining that occurred at what would have been a prestigious royal residence. Naturally, this level of opulence contrasted markedly with the lives of peasants like Witheberd, who had to make wide detours around the vast royal estate just to gather enough to survive.

As archaeological work proceeded in fits and starts, Wright and Gaunt explored the paper trail left by historians. The King’s Houses—now also known as King John’s Palace—were first documented in 1164, when Henry II was on the throne. They are mentioned again in documents through the fifteenth century, spanning the reigns of Richard I, John, Henry III, Edwards I, II, and III, and finally Richard II. By the mid-fourteenth century it was a sprawling complex, with sections such as the Great Gateway, King’s Long Stable (with capacity for 200 horses), Great Chapel, Great Hall, Great Chamber, King’s Kitchen, Chapel next to the King’s Chamber, Queen’s Hall, Queen’s Kitchen, pantry and buttery, the Knight’s Chamber, and private chambers for important

barons, earls, princes, and bishops.

Richard I chose to meet William of Scotland at the King’s Houses in 1194 to bargain over ownership of land. In 1290, Edward I held parliament there. “Both of these events demonstrate that this was a complex capable of accommodating and impressing on a national scale,” says Wright. Unlike nearby Nottingham Castle, the King’s Houses were not fortified. Rather, the estate was intended to be a pleasant location for feasting, hunting, and hawking—aristocratic pursuits fundamental to patronage, political maneuvering, and negotiating treaties. “It was the equivalent of the golf course and attached high-status hotel today,” says Wright, “where business and recreation were combined.”

The palace entered a period of decline during the fifteenth century as the monarchy centered itself in southeast England. A 1525 survey lists just three extant structures—chamber, chapel, and kitchen—and “ther is in great dekay & ruyne in stonework tymber lede and plaster.” An engraving by Francis Grose in 1772 depicts a scene that looks much like what visitors see today.

The ruins are made of local stone and contain a Romanesque doorway. Inside, it is possible to see the remains of beam slots, around eight feet up the wall, that likely once

The ruins of the King’s Houses are modest, but examination of the surrounding landscape has made it clear that they were part of a massive royal complex that had been used during the reigns of at least eight monarchs.



supported a wooden upper floor. And the profile of the ruins indicates a line of first-floor windows. “The Romanesque features suggest that this was one of the first of the palace buildings, constructed during the 1170s by Henry II,” says Wright. Given its size and age, Wright thinks this was most likely the Great Hall. Locating the sites of the other buildings that made up the leisure palace complex, however, has been a challenge. A 2011 survey—undertaken by Wessex Archaeology for the television program *Time Team*—revealed a rectangular building, measuring approximately 25 by 15 feet, to the north of the ruin. Evaluation trenches revealed foundations made of river cobbles and a compacted stone floor surface in one corner. Thirteenth- and fourteenth-century pottery was also recovered, along with a section of a carved stone sculpture of a hand. There’s no definitive evidence to say what the building might have been, but it has been tentatively identified as a chapel.

A walk through the village of Clipstone reveals the possible fate of the other medieval stone buildings. “Once the palace fell into disrepair, it looks like the villagers quickly made use of the stone in their own houses and gardens,” says Wright. In fact, three houses have telltale medieval internal walls. Their location in relation to the 1630 map indicates that the walls could have been part of the original palace gatehouse, still in place after centuries. But these are the only extant structures that have been observed. Other structures, such as the stables, may have been built of timber and would have left little sign that they were ever there.

Though many of the buildings appear to be gone, Gaunt has continued to find artifacts that confirm that the King’s Houses hosted people of high status. The classic medieval assemblage of domestic animal bones, including sheep, goat, cattle, pig, horse, dog, and domestic fowl, was found, along with the bones of wild animals including deer and rabbit. Curiously, most of the deer bones come from the right side of the carcasses. Naomi Sykes from the University of Nottingham suggests that this points toward ritualized butchery, in which only the right side of the carcass was offered up to the very high-status guests at the feast. At Clipstone this would have been the monarch and his household. Other artifacts include a pottery assemblage that hails from far and wide, including exotic material from as far away as northern France.

Metal-detecting surveys have revealed thirteenth- to fourteenth-century horse pendants and book hinges. “These

book hinges provide evidence of literacy and patronage at the site and are representative of the high-status nature of reading and writing,” says Wright. In addition, coinage from the period has also been found, including a continental sterling of Florennes, issued by Gaucher of Chatillon between 1313 and 1322, representing the widespread links that the monarchy maintained during the medieval period.

It is thought that the King’s Houses had ornamental gardens between the palace and the lake. In medieval times, gardens were one of the few places where men and women could freely interact, and it seems that they may have seen their fair share of romantic trysts. According to historical records, King Edward II’s 1315–1316 visit took place around the time that his son, Prince John, was conceived. Richard II also appears to have used the country palace to escape courtly life.

According to Wright, “We know he came here after a difficult row with his own council, and he had a reputation for staying up late, drinking heavily, and being profigate with women.”

The indulgent behavior of the royals and aristocrats didn’t escape the notice of local people, and when those excesses began to encroach on their own lives—when they lost access to what to that point had been common resources—discontent grew. It is easy to see how criminals who targeted the aristocracy might have been admired and mythologized, and it is likely that this is where and when the origins of the Robin Hood myth began.

The landscape surrounding the palace enclosure provides some indications of how the upper classes corralled resources for their sole benefit. Gaunt and

Wright found evidence of the pains that royal houses took to plan and maintain a varied and well-stocked hunting landscape—for their exclusive use. Using the 1630 estate map, Wright tracked down the overgrown remains of a “deer leap.” These earthworks involved a large ditch with an earthen bank on one side. A low fence was placed atop the bank so that small fallow deer could leap over and into the ditch, onto royal property—but not back out. Once in the park, the deer were cossetted. The 1630 map shows a holly plantation established to provide them with winter fodder. When time came to supply the household with venison, hired beaters would drive the deer into a “deer laund,” a large grassy area that is still visible today, to give archers a clean shot.

Beyond the park enclosure, red deer were protected by



Engraving of King Edward II

forest law, which prohibited hunting without the permission of the king. There, on the western edge of the deer park, is a series of five large ponds, fed by the River Maun, and overlooked by a small ruin known as “Beeston Lodge,” thought to be the remains of a fortified tower to protect the ponds. “The ponds were made around 1316, during the reign of Edward II, and kept for provision of fish for the king,” says Gaunt. “They represent a massive undertaking by the crown.”

It was around this time that Edward II made the controversial decision to extend the park by 200 acres, taking access to common forest resources away from local people such as Witheberd. The timing of the expansion was particularly heartless: It followed a run of harsh winters and rainy summers that brought repeated crop failures, livestock deaths, and famine across the country. It seemed that just when the monarchy couldn’t appear more rapacious, they reached out to take more. The strength of ill-feeling after this event is clear in the records of complaints made by the villagers to King Edward III, 10 years after Edward II extended the park. “Documents show that the people appealed to the king to help them out,” says Wright. Interestingly, Edward III responded by dismantling the buildings associated with the fortified tower, but not the tower itself. And he kept the 200 acres, though he allowed some of it to return to common use. Today, there is at least one thing to thank the kings for: Landowner Michelle Bradley says, “The ancient forest we see around us today wouldn’t have survived without the king’s palace.”

In a time when appeals to the king fell on deaf—or at least tone-deaf—ears, it is easy to imagine how tales of a heroic outlaw might take hold. “I think myths arise in the gaps between social reality and ideology,” says Lesley Coote, an expert in medieval literature at the University of Hull. “People need myths because they can’t always live up to their own aspirations.”

Historians generally agree that either Edward I or Edward II is most likely the king named “Edward” in one of the earliest written Robin Hood tales, *Lytell Geste of Robyn Hode*, first printed around 1520, though likely told and shared long before. The earliest known reference to the outlaw himself

emerges in the narrative poem *Piers Plowman*, written by William Langland in the late fourteenth century:

*I kan noght parfitly [recite] my Paternoster as the preest it syngeth
But I kan rymes of Robyn Hood and Randolph Erl of Chesbre.*

“In this passage a priest is being lambasted for knowing the popular tale of Robin Hood better than he knew his ecclesiastical texts,” explains Wright. “It shows that the stories of the outlaw were already well established by this period.”

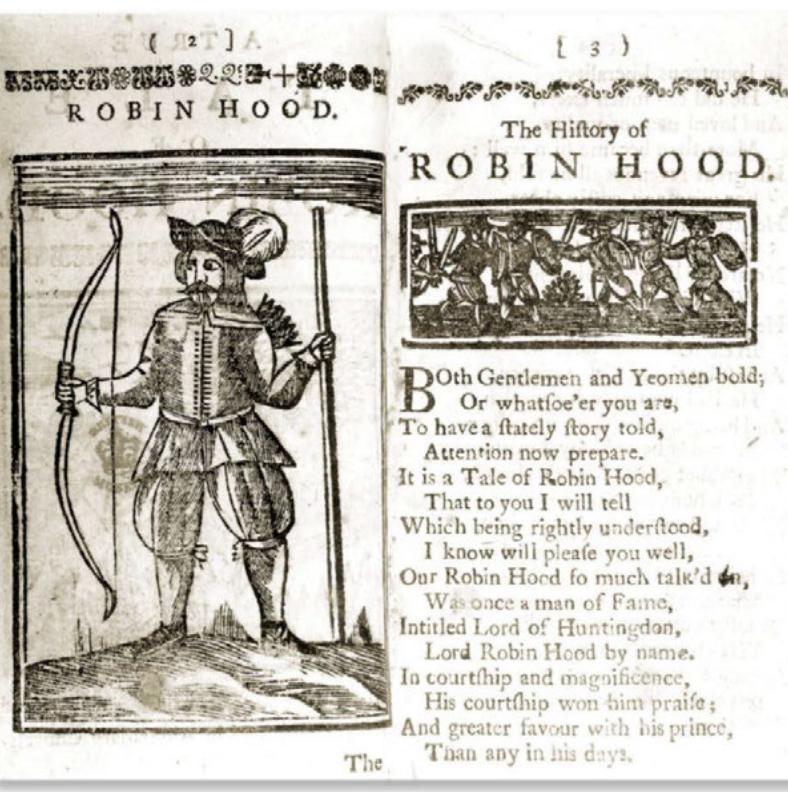
Both Edwards spent a large amount of time at their Nottinghamshire base. Edward I expanded the King’s Houses greatly, ordering the rebuilding of royal apartments there in 1280 and the construction of the King’s Long Stable in 1283. In 1290 he even held parliament there. Meanwhile, Edward II also spent considerable time at the country palace. “Because of the Scottish situation and then the civil war with the Earl

of Lancaster [whose sphere of influence lay just north and west of the Nottingham/Derby area], Edward II was particularly ‘present’ further north, and for longer than was usual,” explains Coote. He certainly wasn’t liked in this region, with documentary evidence revealing that he was advised to take extra men for protection when he passed north of Sherwood Forest.

All of this makes a strong circumstantial case that the legend of Robin Hood could have emerged there, during the reign of either Edward I or Edward II. “My experience is that ‘folk’ memories usually have a basis in truth,

although this may be tangential to what actually happened,” says Coote. “It is a big leap of faith to say that was the beginning of Robin Hood—and I wouldn’t make this leap—but there may be general folk memory of needing to poach during times of famine lying behind the idea of the outlaw living off the king’s deer, for example.”

The King’s Houses are providing fresh archaeological evidence—with more to come from the expansive site—of the habits and behavior of medieval royalty. And the endurance of a story that dramatizes opposition to that behavior keeps showing just how powerful the feeling of being powerless can be. In the absence of kindling, a hero would have to do. ■



17th-century woodcut from *The History of Robin Hood*

Worlds Within Us

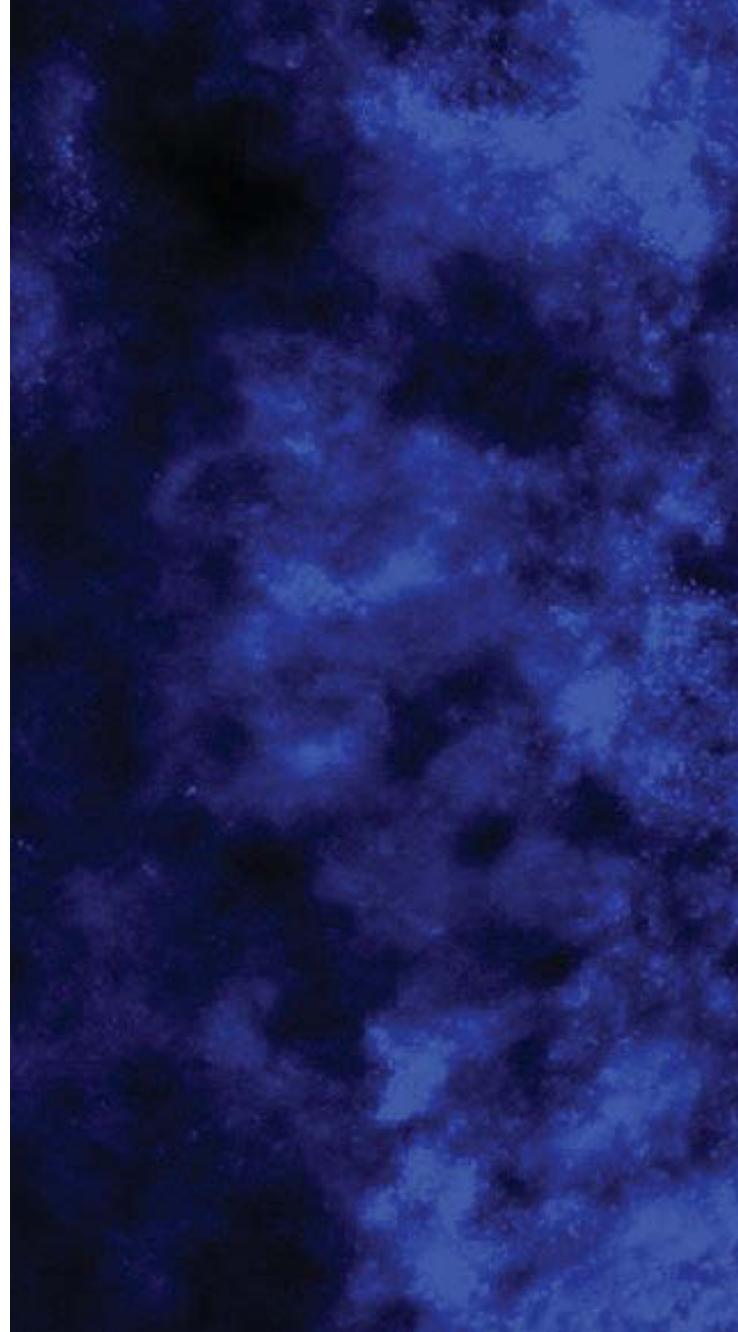
Pulled from an unlikely source, ancient microbial DNA represents a new frontier in the study of the past—and modern health

by SAMIR S. PATEL

THE LARGEST ANCIENT DNA laboratory in the United States sits behind a heavy steel door in a plain service hallway at the University of Oklahoma. Inside, researchers find, extract, isolate, and amplify DNA molecules and proteins, producing voluminous mounds of data that can address grand, complex questions about migration, diet, and human health—in the deep past and today. They’re probing the limits of new methodologies. They’re encountering the advantages and pitfalls of interdisciplinary science. And they’re writing the first drafts of a new chapter in archaeological research. But before they can do any of this, they have to ensure that the lab is scrupulously clean.

Next to the door, a red button, when pressed, produces a satisfying thump and turns off powerful UV lights inside. A series of pressure gauges climbs next to it. The lab’s six rooms are kept under positive pressure, double-sealed, and have their own air supply, filtered free of anything larger than 1,000 daltons—the mass of just 1,000 hydrogen atoms. People who enter must take off their shoes, change into scrubs, and, by the time they reach the two innermost rooms, don Tyvek suits, surgical masks, hairnets, and face shields. Those chambers are free of anything extraneous: Only sample vials and scientific equipment are visible. The DNA and proteins that the researchers work with there come from ancient microbes, and keeping the lab free of contamination is a tall order in a world that is positively swimming with their modern counterparts.

“Usually, ancient DNA work is performed in dungeon-like labs located in windowless basements,” says Christina Warinner, anthropologist and codirector of the Laboratories of Molecular Anthropology and Microbiome Research



(LMAMR). This lab, however, is fitted with picture windows that face the atrium of the university’s Stephenson Research and Technology Center, so visitors can watch the scientists and students inside process microscopic genetic samples that can be centuries or even millennia old.

The microbes that are the focus of the LMAMR—from both ancient and modern sources, with separate lab facilities for each—come from what is known as the human microbiome, the myriad communities of bacteria (as well as eukaryotes, viruses, and archaea) that reside in and on our bodies. In only the last few years researchers have begun to understand that studying how the microbiome has shifted over thousands of years, particularly at moments of great change in human history, has the potential to reveal some of the ways in which how we eat, live, and move around the world have affected human biology. Any number of questions—medical, archaeological, demographic, evolutionary—that were unframeable just five



years ago can now be asked and ultimately answered on scales ranging from molecular to continental.

THREE ARE, ACCORDING TO the latest estimates, something like 30 trillion human cells in your body. Alongside them, throughout your gut, in your mouth, on your skin, there are even more—40 trillion, give or take—individual bacteria. Together they make up 2 percent of your body weight, roughly equivalent to the weight of your brain, and carry some 3.3 million genes, to your paltry 22,000. Like every other multicellular organism, we coevolved with them, we incorporated them into our cells, we’re built from them. We may think ourselves individuals, but we’re each a multitude.

The term “microbiome” isn’t yet two decades old but it is already clear that these communities have a profound impact on human health. In addition to critical roles in oral and digestive health, the microbiome has been associated in some way

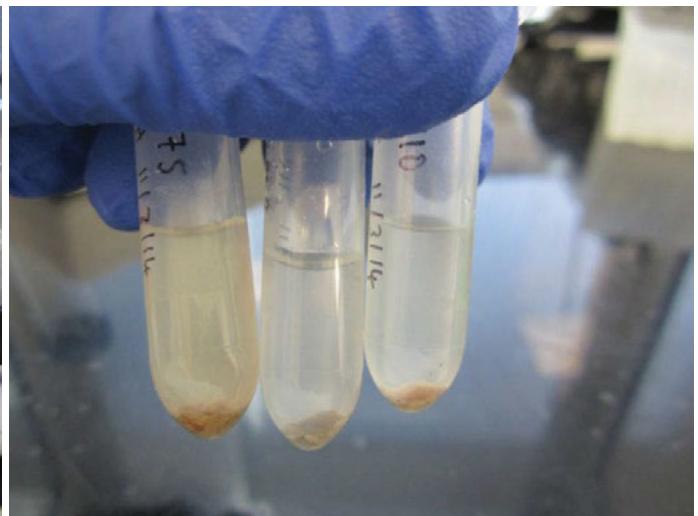
This image of DNA dating to approximately 1,000 years ago comes from a piece of mineralized dental plaque, or calculus, that was processed and then stained with a dye that latches onto DNA molecules. Dental calculus has proven to be the richest known source of ancient DNA in the archaeological record. Much of this genetic material—hundreds of millions of genomes are visible here—comes from the microbiome, the communities of microbes that live in and on the human body.

with everything from mood disorders to cardiovascular disease, from autism to rheumatoid arthritis, not to mention countless infectious diseases. The old idea of sickness being caused by individual bugs is now giving way to a much more complex microbial ecosystem model. “On balance it is very clear that the microbiome plays a fundamental biological role,” says Warinner.

The microbiome is a key point of contact between humans and the world around them. It is affected by—and therefore may reflect—changes in how we manipulate our environments and in what we consume. And we change with it. The Neolithic Revolution, for example, saw the rise of agriculture and settlement. The last 150 years have brought the Industrial Revolution, megacities, modern hygiene, processed foods, and antibiotics. They’ve also seen a rise in the incidence of chronic disease: cardiovascular ailments, autoimmune disorders such as asthma and allergies, and metabolic disease such as obesity and diabetes. Experts speculate that changes to the microbiome could be a significant link between lifestyle and health. But examining such connections means knowing how the microbiome has changed—and that means knowing what it *was*.

The gut is our most prolific microbial ecosystem, and evidence of ancestral microbiomes—these microbial communities vary by place, time, and culture—though rare, has been found in coprolites, or preserved feces, in particular by LMAMR codirector Cecil M. Lewis, who also studies the modern gut microbiome. But the gut is just one microbial hub in the human body. In your mouth, right now, there are hundreds of species of bacteria, living in nine major niches, including below the gums, on the cheek, and in the saliva. The mouth is the microbial equivalent of a rainforest, teeming with creatures, interspecies warfare, cataclysms. Some of these residents form a film on your teeth, colonies stuck together with DNA, proteins, and polysaccharides. Left unbrushed, this plaque, for reasons that aren’t really known, occasionally fossilizes in your mouth to form tartar, dental calculus. Calculus is tough and almost universally observed clinging to the teeth of adult skeletons discovered at archaeological sites. For many years this material was ignored, discarded, and otherwise overlooked, as were human bones prior to the introduction of modern archaeological practices. “We’ve always thrown stuff away—and that stuff becomes revolutionary,” says Greger Larson, director of the Palaeogenomics & Bio-Archaeology Research Network at the University of Oxford. “If you don’t understand that it exists, then you can’t understand its power.”

WHEN COURTNEY HOFMAN, a researcher at the LMAMR who has since joined the full-time faculty there, begins the DNA extraction process,



The ancient DNA lab at the University of Oklahoma (top) is kept to the highest standards of cleanliness to limit the risk of modern contamination. Students and researchers process samples (above left) to isolate DNA from dental calculus or coprolites. The genetic material (above right) floats invisibly in solution.

the first thing that registers is the sound. She takes a dental scaler to a 2,000-year-old tooth from Spain and produces the raspy scratching and resonant clinks familiar to anyone who's had their teeth thoroughly cleaned. After a moment, the tip of the scaler finds purchase and a fragment of calculus pops loose. Hofman does the same with a few more teeth, wiping everything down between each step to limit the possibility of contamination. "We go through a lot of bleach here," she says.

Each sample goes into a tiny vial to be decontaminated with UV light, and is then crushed, rinsed, and demineralized, leav-

ing behind a gauzy pellet. After a spin in a centrifuge, DNA from 2,000 years ago floats invisibly in each vial. This is the most sensitive part of the process, as the protective calculus is gone. Next, the DNA must be purified and processed for sequencing and analysis.

As a source of ancient biomolecules, calculus differs from coprolites. They contain distinct microbial ecosystems, of course, and preserve very differently. Coprolites are open systems, subject to the elements, contamination, and domination by soil microbes. Calculus, on the other hand, fossilizes

while you're still alive. But it wasn't clear until very recently—through Warinner's work and parallel projects in labs in Chile, Australia, and Denmark—that calculus traps or preserves DNA at all. "Dental calculus is really an unlikely hero," she says.

Warinner, who had excavated the earliest known epidemic mass graves in Mesoamerica early in her career, began to see the potential in calculus in 2007, when she worked at the Smithsonian. A colleague there was Amanda Henry, now at the Max Planck Institute in Leipzig, who searches calculus for trapped plant fragments, such as phytoliths and starch grains. By 2010, Warinner was a postdoctoral researcher studying ancient disease and diet at the Institute of Evolutionary Medicine at the University of Zurich. When she tried to replicate Henry's methods there, she had trouble counting plant granules. "There were so many bacteria that were getting in the way," she says, "but I had a kind of aha moment." Other research groups were exploring the same idea, but at the time nothing had been published, other than a review article from the 1950s that stated that there was no DNA in calculus. She saw an opportunity to test her hypothesis that it could be a source of ancient microbial DNA, but it was a risky, expensive proposition for a postdoc. "People thought it was just a nuts, *nuts* idea," Warinner says. "I was sort of doing microbiome research without knowing the word."

"In German we say *überflieger*; that means someone who flies higher than the others. I could immediately see her potential," says Frank Rühli, director of the Institute. But the calculus idea didn't seem promising. "I was a bit reluctant at the very first moment." Warinner's first few attempts in 2010 failed. She then got a more sensitive fluorometer, and it still didn't appear to be working. "I saw a message that I didn't even know existed," she says. "It said 'Error, DNA too high.'" So she diluted the sample 50 to 100 times. "I started realizing, as I started quantifying, that I had just discovered the richest source of ancient DNA ever described in an archaeological sample." There was more DNA in her sample than there is in fresh liver tissue.

In the few years before these first experiments, several scientific currents were converging. In 2008, Lewis, who didn't yet know Warinner, published some of the first reports of the ancient microbiome from coprolites. The same year, the Human Microbiome Project (HMP), a multi-institution effort to catalogue the biota, was established with funding from the National Institutes of Health. This placed the term and its connection to human health in wide view. Microbes had long been seen only as biological villains to be exterminated, but with the launch of the HMP came the recognition that bacteria could be helpful and even essential to multicellular life and its processes. This was a seismic change.

Perhaps most importantly, genetic research itself was undergoing a revolution. Gone were the days of laboriously generating one DNA sequence at a time. The new wave of technology, called next-generation sequencing (NGS), was becoming widely available, and is able to create hundreds of millions of sequences at once. It opened the door for "shotgun metagenomics," or amplifying and sequencing all the DNA

from all the genes from all the organisms in a sample. NGS has made it possible, in a single pass, to describe entire microbial communities or reconstruct the full genome of a microbial species. It increased exponentially the amount of data researchers could gather. According to Warinner, "We were just racing as fast as we could to keep up with all of this."

NGS, however, was expensive—the necessary reagents alone cost \$13,000 for the experiment that Warinner planned to conduct. She was terrified, and thought at the time, "It's a moon shot. If it works, it's awesome. If it doesn't, I'm hosed."

DALHEIM IS A SMALL TOWN near Lichtenau, Germany, where in 1989 and 1990 the Westphalian Museum of Archaeology excavated the site of a medieval monastery, parish church, and convent. Remains from the 151 burials they uncovered were stored at the University of Mainz until the school needed the space and planned to incinerate and bury them. Rühli offered to bring the skeletal material to Zurich for research in 2010. "A big challenge when you're trying to develop a new method is just having material to practice on," says Warinner. While she was conducting her work on the Dalheim samples, several other groups were operating with the same idea. In 2012, researchers from the University of Chile were the first to publish the basic identification of DNA in archaeological dental calculus. A group led by Alan Cooper of the University of Adelaide was the first to apply NGS to it in 2013. Following these reports, the Dalheim burials offered Warinner an opportunity to produce the first shotgun metagenomic analysis and characterize complete ancient oral microbial communities. The Dalheim study stands now as the most forceful declaration of the possibilities of dental calculus, with orders of magnitude more data than had been reported before. The experiment resulted, Warinner says, in hundreds of millions of sequences. It took three years to analyze it all.

Warinner and her coauthors—32 in total from a broad range of disciplines—catalogued, from the mouths of four medieval individuals, 40 opportunistic pathogens, including species associated with cardiovascular disease, meningitis, and pneumonia, as well as what might be the oral ancestor of modern gonorrhea. They sequenced the entire genome of *Tannarella forsythia*, a cause of periodontal disease. They saw dietary DNA from pigs, cruciferous vegetables, and bread wheat. They looked for proteins as well, and found ones associated with pathogen virulence, others produced by the human immune system, and beta-lactoglobulin, a durable dairy protein. Among the genes identified, oddly, are ones associated with microbial antibiotic resistance—hundreds of years before the advent of antibiotic drugs. The expert on the subject for the study, Lars Hansen of Aarhus University in Denmark, says that the cellular machinery that creates antibiotic resistance can serve other purposes in cells. The modern phenomenon, he explains, comes from increased availability and expression of these existing mechanisms. "It is the first time [antibiotic resistance sequences] have been found in an ancient human-associated context," says Hansen. "It shows that these building blocks are basically everywhere."

The study has spun off in dozens of directions. For example, the LMAMR is using the presence of the milk protein to study the origins of dairying practices all over the world. Another of their studies announced the reconstruction of a full human mitochondrial genome from calculus alone. This affirms calculus as a possible alternative source of human DNA in cases, such as with Native American remains, where it is not permissible to sample bone. Archaeologist Mark Aldenderfer from the University of California, Merced, along with Warinner and her team, is studying the genetic adaptations that allow people to live and thrive at high altitudes in Nepal and Peru. The LMAMR is also collaborating with archaeologists who work in the Caribbean to see how well calculus preserves DNA in climates generally unfriendly to ancient biomolecules, and to study migration and colonialism alongside archaeological and linguistic evidence. And in the study that Hofman is working on, some 20,000 years' worth of samples from a site in Spain are being examined to look for changes in pathogens, proteins, and microbial community structure over time in a single place. The origins and evolution of specific diseases can be examined as well—typhoid, tuberculosis, plague, syphilis. “We don’t know what the limits are yet,” says Warinner.

Another step in this research concerns the study of proteins, or proteomics. Proteins, which are also found in calculus, may persist much longer than DNA and reflect the actual expression of genes. According to Lewis, “That’s going to change everything.” One thing that proteomics may be able to show is direct interaction between microbes and the human immune system. Matthew Collins, an LMAMR collaborator and specialist in ancient proteins with the Universities of York and Copenhagen, compares proteins in calculus to the port of an ancient city destroyed suddenly and preserved in situ. The calculus holds evidence, in proteins, of ongoing battles between “migrant workers” and the “local police force.” “The body fights against infection and you can see the bugs fighting back,” he explains. “You’ve got this whole dynamic system preserved there.” The work will require innovation and refinement in extraction and analysis, but the potential is vast.

Research is going forward, but it remains in its early stages, and will have notable pitfalls and hurdles to overcome. The LMAMR, working with Kirsten Ziesemer of Leiden University in the Netherlands, has already identified one of these problems. Apparently a gene segment called 16s, commonly used to identify species from their DNA, can’t be relied on for conventional genetic analysis of ancient microbes because of the way it breaks down over time. The array of processes and methods is complicated and has yet to be standardized. “One of the problems has been, in microbiome research in general, that different methods of extraction produce different results, different computational pipelines produce different results,

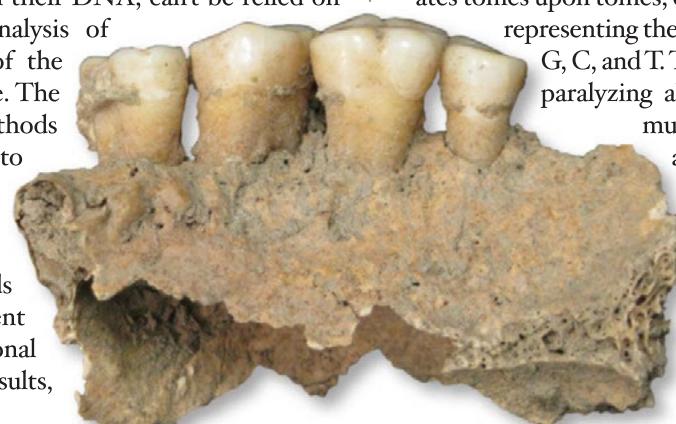
different sequencing platforms produce different results, different primer sets produce different results,” says Camilla Speller, another LMAMR collaborator from the University of York. There’s a lot of troubleshooting before innovation can become practice. “This is a problem,” Lewis says, “of being on the frontier.”

AT THE LMAMR, after the calculus has been demineralized, the scale of the work goes from tiny to microscopic to molecular. The DNA floating in the solution has been broken down by time into fragments, from just a few base pairs up to maybe 100 in length. Conveniently, next-generation sequencers are designed to work on DNA fragments of about that length, around 50 to 100 base pairs. The samples are treated with a series of enzymes, buffers, and primers, and attached to segments of synthetic DNA. These manmade genetic fragments, which can later be excised from the data, are used to fill in gaps, tag each sample with a unique genetic barcode, and make the samples machine-readable. This process is called “building a library.” The library is then “read” at a genomics facility, such as the Yale Center for Genome Analysis, and what comes back is a stream—a tsunami, really—of data.

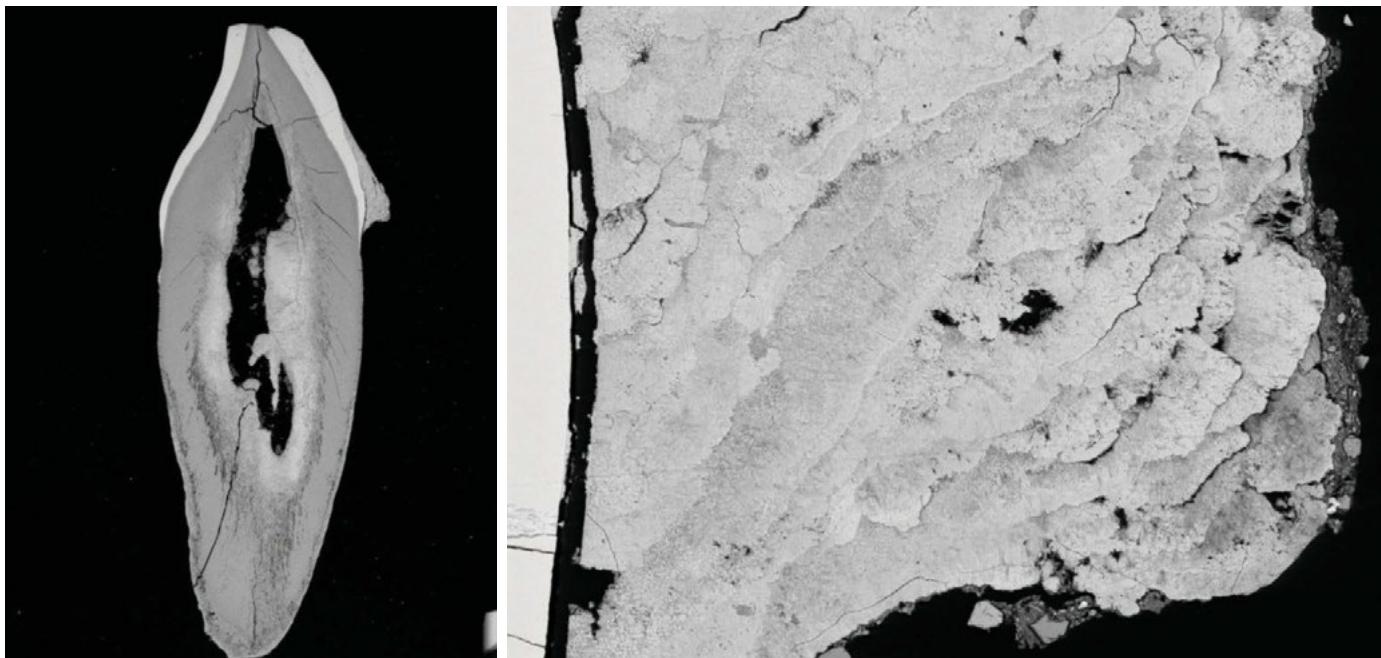
The quantity is intimidating. “I wouldn’t say it’s a wall, but I’d say it’s a very steep mountain,” says Warinner. According to LMAMR codirector Krithi Sankaranarayanan, who is a microbial ecologist adept at data analysis and interpretation, the next steps also include confirming, on the basis of damage patterns, that the DNA is indeed old. The reads are then assembled and modeled and interpreted to create longer and longer sequences: partial genes, full genes, and even complete genomes. Then the researchers must try to manage and corral these massive data sets to make them comprehensible. They pool them, build frequency tables, parse species into different bacterial groups. They look for questions and structures and layers that bring order. Modern computing power is staggering, but analysis still takes days or weeks.

If the whole thing sounds Borgesian, that’s because it is. Jorge Luis Borges imagined the universe, in his 1941 short story “The Library of Babel,” as an infinite library containing every possible combination of the alphabet—an expanse of gibberish concealing magical insights. The librarians there are wandering mendicants driven to superstition, madness, and worse. In today’s research, even a single sample of calculus creates tomes upon tomes, composed of patterns of four letters

representing the nucleobases that make up DNA: A, G, C, and T. There is a seemingly limitless, global, paralyzing abundance of potential samples in museums, archaeological collections, and unexcavated sites. Complicating matters, the databases against which these DNA patterns are



Dental calculus is almost ubiquitous in the archaeological record and can be seen encrusting teeth on this mandible fragment from the site of Dalheim, Germany.



Scanning electron microscope images reveal a cross-section of a calculus-bearing tooth (left) and the structure of calculus itself (right). Calculus forms when dental plaque, a bacterial biofilm, occasionally mineralizes. Its layered structure traps and preserves DNA and proteins from the human host, the microbiome, and dietary sources.

checked are imperfect, skewed toward specific species that have been studied because of their potential impact on human health or agriculture. There's also DNA "dark matter," or sequences that don't match up with anything that has been described or characterized—undiscovered biology. Interpretation requires knowledge of these flaws, computational mastery, a global perspective, and savage, callous skepticism.

Taking data sets so large that they can only be contemplated through summary statistics or pure abstraction and working them into the discipline of archaeology is a challenge. But this new methodology certainly isn't the first time that archaeologists have had to come to grips with scientific innovation. Radiocarbon dating, isotopic signatures, and remote sensing have all become regular analytical tools. Similarly, geneticists have to begin to acknowledge and understand the language and questions of archaeologists.

"There have been revolutions in archaeology before, and archaeologists have been able to adapt to them," says Hannes Schroeder, who studies ancient DNA and the Caribbean at the Natural History Museum of Denmark, and is also working with LMAMR. "But none of these other fields are as demanding in analytics, techniques, and working with the data as what is happening now with ancient DNA." For York's Speller, it means that archaeology is growing in a new direction, one that includes computer science and medical bioscience.

Warinner and Lewis at the LMAMR, and a number of other researchers looking at the ancestral microbiome, have backgrounds and experience in archaeology and anthropology. "The goal is to find common questions we're really interested and invested in," says Warinner. "The challenge of a scientist is to chart a path through these questions so you don't get totally overwhelmed by them. It is such enormous territory."

At the moment, the areas most suited to examination through the lens of ancestral microbiomes are big ones—the peopling of continents, agriculture, migration, exploration, colonialism, industry, globalism. Researchers want to know what these transitions mean for the shape of the modern world—specifically, who we were and who we are, physically, genetically, microbially. We can now investigate patterns, identify specific bacteria or entire microbial communities that have been lost, and attempt to understand what they did for us after tens of thousands of years of coevolution. We might also ask whether we can get them back, or if we even want to. "Now that we know so much about the microbiome, it's very hard to think of ourselves solely from the perspective of our genome," says Warinner, "because if you just have genomic information you're missing such a huge part of the biology that it's almost irresponsible not to consider it."

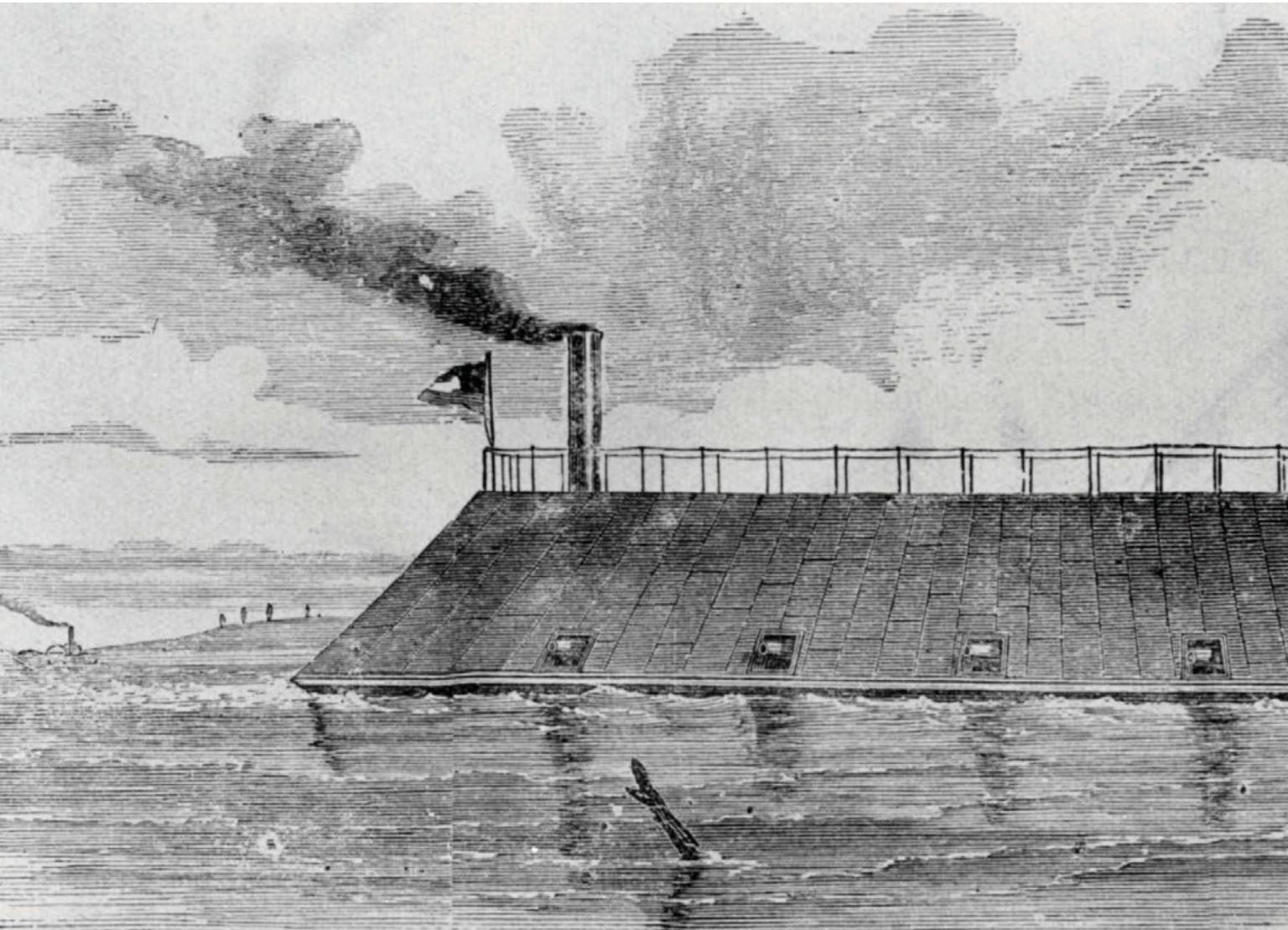
In the late seventeenth century, Dutch draper and scientist Antonie van Leeuwenhoek looked through one of his pioneering microscopes at a sample from inside his own mouth. He found it crawling with what he called "animalcules." Science perhaps still has moments of revelation, but more progress comes from patience, technological refinement, some new algorithm or process, and ways to think around dead ends and blind alleys. Innovations developed this way build upon one another to a point at which we can see a gene associated with antibiotic resistance in the mouth of a medieval German nun, and this helps us understand something about cellular machinery—machinery that happens to be at the root of a modern healthcare crisis. "I feel," says Warinner, "like we're standing at the beginning of a new branch of archaeology." ■

Samir S. Patel is deputy editor at ARCHAEOLOGY.

A SPLENDID FAILURE

The wreck of *CSS Georgia*, a unique Civil War relic, emerges from Savannah's harbor

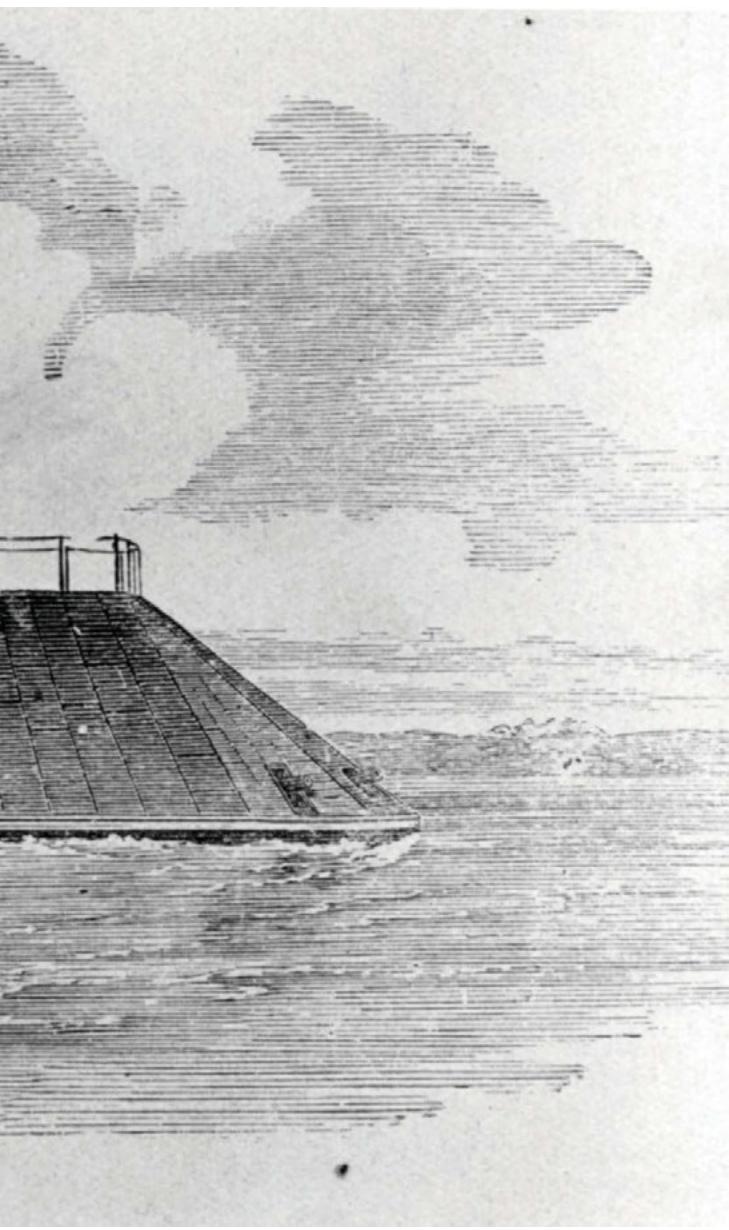
by MARION BLACKBURN



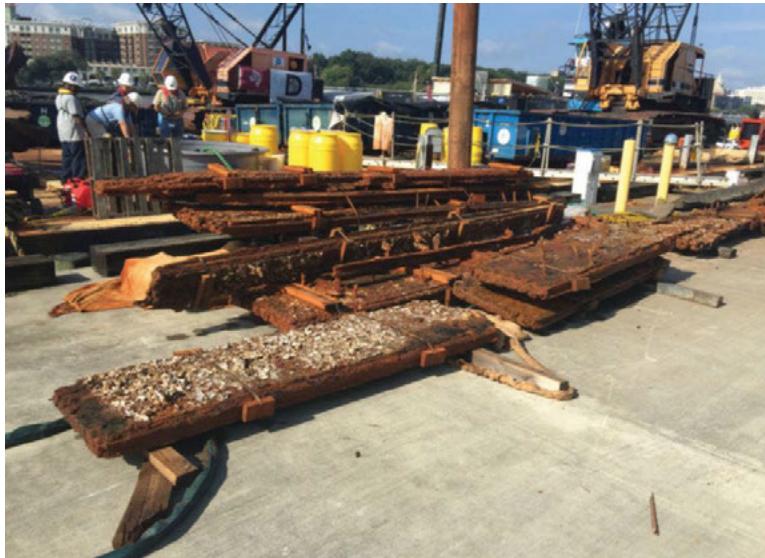
THE CONFEDERATE IRONCLAD RAM "GEORGIA."

Our iron floating battery is a splendid failure. She has been taken down between the forts and they are obliged to keep her engines at work the whole time to prevent her sinking, she leaks so badly. The officers had a consultation, a day or two after she went down, to decide on the propriety of throwing over her coal to keep her afloat. During the long storm last week, she leaked also from the roof, so that there was not a dry spot for the men or anything else in the vessel, even their beds were wet.

—Savannah resident Mrs. Edward F. Neufville,
September 2, 1862



PRIOR TO THE OUTBREAK of the Civil War, Savannah was—as it is today—a jewel of the South, often compared with New York for its prosperity, vibrancy, ethnic and religious diversity, shopping, and culture. Early 1862, however, brought with it the Union's Anaconda Plan, a naval blockade of important Confederate ports, and with the April seizure of nearby Fort Pulaski, Savannah's harbor—the mouth of the Savannah River—was closed for business. But the city remained, for a time, well defended. The earthen walls of Fort McAllister, to the south, were stout, strong tidal currents made navigation perilous, and deliberately sunk boxes of debris, stones, bricks, and sand, called “cribs,” would damage any Union vessel that strayed too far upstream. There was also a strange, unwieldy, railroad-track-sheathed hulk that watched over the harbor: CSS *Georgia*, an ironclad boat so bizarrely designed that it could barely move under its own power. Built

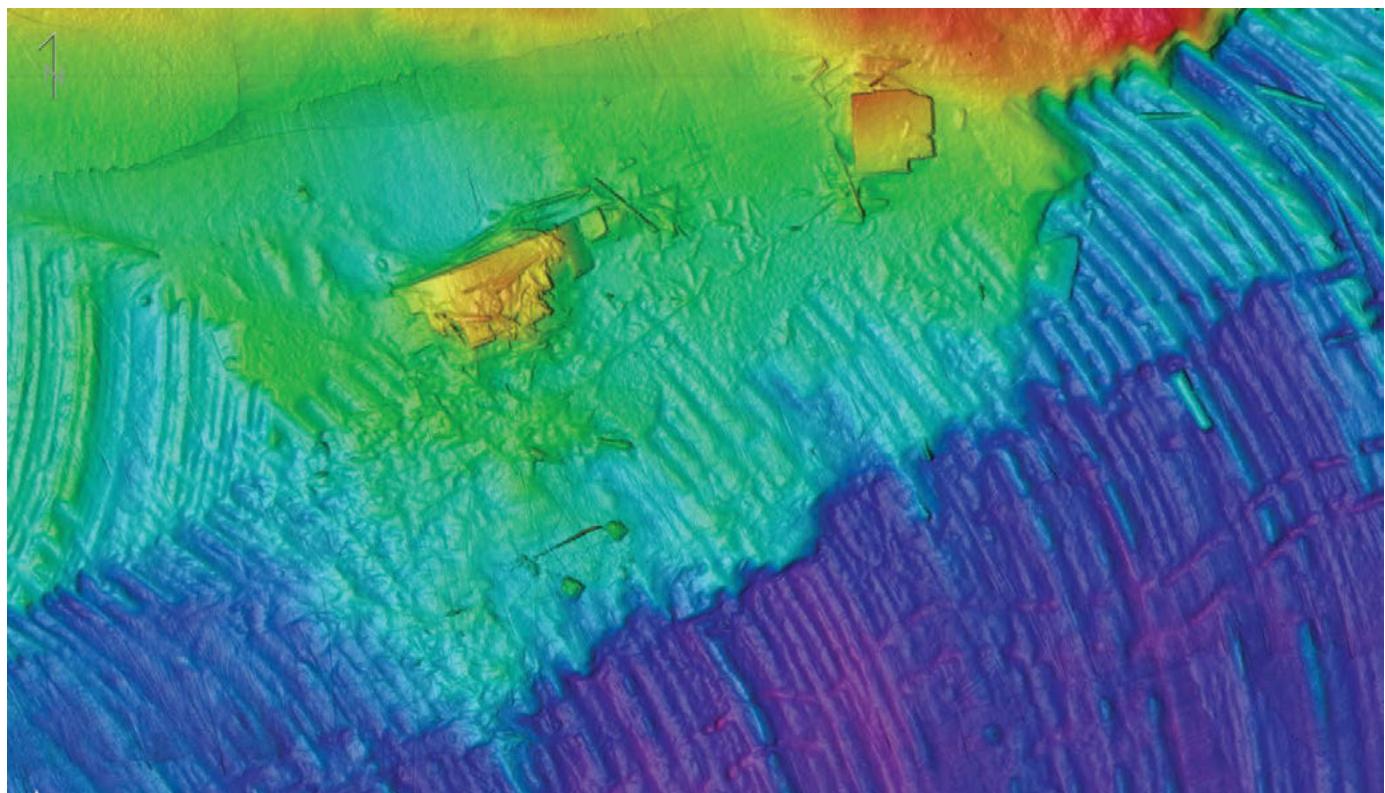


Built in 1862 and 1863, the Confederate ironclad CSS *Georgia* (left) defended Savannah's harbor and was scuttled as Union forces took the city. After the Army Corps of Engineers was tasked with deepening the harbor, in 2015 portions of the ship's armor (above) were raised and studied.

in 1862 and 1863 with charity funds, the limited materials the blockaded city had on hand, and more gumption than wisdom, *Georgia* was less a warship than a floating gun battery—and a barely floating one at that.

Georgia and the city would never be challenged from the water. The Union instead came overland from the west. In November 1864 Savannah residents were alarmed by word that the Union general William Tecumseh Sherman had departed Atlanta with some 62,000 men on a mission he later described as “not only fighting hostile armies, but a hostile people.... [We] must make old and young, rich and poor, feel the hard hand of war.”

The goal of Sherman’s March to the Sea was to cut a swath through enemy territory, meet up with the Union navy, and then take Savannah. On December 13, one of his armies was



A multibeam sonar scan revealed that significant parts of the wreck of *Georgia* remained on the riverbed, despite extensive salvage of the site in 1868. Combined with GPS data, the scan helped guide divers to areas of interest.

able to seize Fort McAllister in just 15 minutes. A few days later they took possession of the city itself, and the mood on *Georgia* turned desperate. To prevent capture of the ironclad, Confederate sailors stopped its pump (*Georgia* was a leaky monster) and opened the windows. The behemoth filled with water and dropped 40 feet to the bottom of the Savannah River.

The war ended a few months later, and though the blockade was lifted, scarcity continued in Savannah. *Georgia*, though settled in the mud, was still visible at low tide—a navigational hazard, an eyesore, and a bonanza for salvagers. In 1868, using old Confederate ordnance, the ship was deliberately blown up to dislodge its iron, and whatever was movable was hauled up. Time and tide buried the rest of the “splendid failure,” and it would stay put until 2015, when a major project explored the wreck site in detail. The \$14 million excavation, under the supervision of the U.S. Army Corps of Engineers, along with the U.S. Navy, Georgia Ports Authority, private consultants, and conservators from Texas A&M University, has yielded thousands of artifacts, along with pieces of the ship’s armored exterior. The project is considered one of the largest archaeological excavations of a maritime site in American waters. Archaeologists, who worked from damp, chilly winter to hot, humid summer to rainy autumn, are learning a great deal about the unusual construction of the ship, the resources available to the blockaded city, and the daily lives of the Confederate soldiers aboard. *Georgia* stands as an unusual symbol of the Confederacy: determined but desperate, entrenched but ill-equipped, proud but doomed.

THE CIVIL WAR USHERED in the age of the ironclads. The first clash among them took place on March 9, 1862, during the Battle of Hampton Roads, when the Union *Monitor* jousting with the Confederate *Virginia*, which had been built from the wooden-hulled *Merrimack*, a Union ship salvaged by the Confederacy. The engagement, also known as the Battle of the *Monitor* and *Merrimack*, was more or less a stalemate, but stands as a landmark in naval warfare.

At the time, ironclads were state of the art and great sources of pride for both sides of the war. Early on, the Confederacy excelled in their construction, developing the casemate ironclad design used for *Virginia*, which, rather than having a gun turret like *Monitor*, simply had guns protruding from its sloping, heavily armored sides—halfway between a traditional wooden frigate and a modern warship. They were like floating steam-powered castles flying the Stars and Bars.

The residents of Savannah rallied around the cause of building a casemate ironclad of their own, a project spearheaded by the Ladies Gunboat Association, which raised \$115,000 for construction. The South was already struggling under the blockade, and Savannah lacked the industrial base to manufacture iron sheathing. What they did have was railroad track, so that’s what builders used, attached to thick wooden backing. Engravings indicate the “Ladies Gunboat,” as it was known, was about 160 feet long and 55 feet abeam, with a 10-foot draft. Its iron casing may have weighed more than 1,500 tons, attached to 15 inches of wood. Its sloping sides extended about 24 feet above the waterline. These dimensions, like so much

about *Georgia*, including exactly how it was put together, are historical conjecture. No written plans remain, if they ever existed. “I’m sure there were concept drawings, but where they ended up, no one knows,” says Julie Morgan of the Army Corps of Engineers, lead federal archaeologist for the project. “It’s another mystery of the *Georgia*.¹”

IN JANUARY 2015, with ice on the boats and docks, Stephen James, an archaeologist with Panamerican Consultants, and coinvestigator Gordon Watts of Tidewater Atlantic Research boarded a small motorboat from an Army Corps of Engineers dock on Hutchinson Island. They traveled down-river to a barge anchored about 800 feet from Fort Jackson. There, they began a painstaking survey of the *Georgia* site, working 10- to 12-hour days in cold, wet, “pretty miserable” conditions, says Watts.

More or less forgotten for more than a century, the site of *Georgia* had been rediscovered in 1968. In 1986 minor excavations brought up a rifled cannon and howitzer, and in 2003 a survey was conducted. Nothing else was done with the site until officials decided that Savannah’s harbor needed to be deepened. According to the Georgia Ports Authority, Savannah is the fourth-busiest container port in the United States. The recent expansion of the Panama Canal allows larger container vessels, and ports will have to be large enough to

the site of *Georgia*. Archaeologists had to labor under a firm deadline to document and retrieve as much of the ironclad as they could.

Beginning in January 2015, a state, federal, and private team began a multibeam sonar scan of the site. The technology sends sound waves out in a 45-degree angle from beneath the research platform and measures the time it takes for the signal to travel down the riverbed and back. “It gives you thousands of data points that map everything on the bottom,” Watts says. They combined this information with GPS data to guide divers to specific artifacts and areas of interest.

The divers were required to use surface air, and had helmets that allowed them to talk to commanding officers and archaeologists above. In addition to very limited visibility in the silty river, they also had to contend with near-constant fluctuations in current and depth. The Savannah River has a dramatic tidal range—one of the largest on the East Coast, with its depth varying by as much as 12 feet between high and low tides. This creates powerful currents that permit only two 90-minute diving windows each day.

The divers from Panamerican Consultants who conducted the initial operations did not know what they would find, but *Georgia* proved to be a rich site. By late spring, archaeologists had retrieved about 1,600 artifacts, among them six sets of shackles (used by Confederate officers to keep certain men on

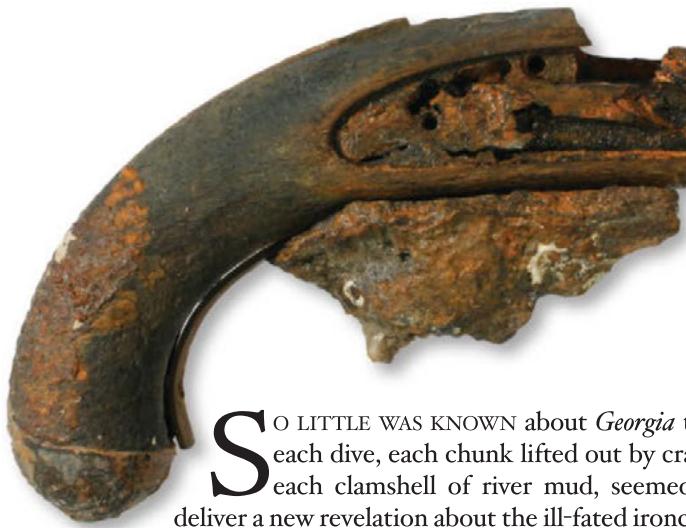


Diving operations were conducted from a barge (above left) anchored at the wreck site, but were limited by low visibility and strong currents. Large floating cranes (above right) were used to lift heavy items such as cannons.



handle them, so the Army Corps of Engineers had been tasked with deepening Savannah’s from 42 to 47 feet. *Georgia* was in the way. In addition to being a navigational hazard, *Georgia* is archaeologically unique and listed on the National Register of Historic Places. Moreover, it is a captured “enemy” vessel, so the ship and its contents, including unexploded ordnance, belong to the U.S. Navy. For all these reasons, an excavation was planned. In 2013, a section of the ship’s armor was raised in a preliminary effort. In 2014, the harbor expansion began in earnest—a \$700 million operation moving steadily toward

the ship and not carousing in town), grapeshot, glass bottles, ship gear such as hooks and pulleys, creamware, and Native American pottery. Soon they were joined by U.S. Navy divers, including specialists in explosive ordnance disposal. This phase of the excavation focused on bringing up lighter artifacts that did not require cranes or other supportive gear. For the last phase of the operation, from summer into fall, the Army Corps of Engineers brought in cranes and heavy machinery to lift larger, heavier pieces and used clamshell dredges to lift silt from around the wreck.



A Confederate musket was among the thousands of artifacts retrieved from the wreck of *Georgia*.

SO LITTLE WAS KNOWN about *Georgia* that each dive, each chunk lifted out by crane, each clamshell of river mud, seemed to deliver a new revelation about the ill-fated ironclad.

Questions were answered at a furious clip regarding how the ship was built, what went wrong with it, and what life was like for the Confederate sailors on board. Many of these findings point to the limited resources and expertise of the blockaded city, and the mix of ingenuity and compromise that characterized much of the South's war effort. "The North made new," says Morgan, "while the South made do."

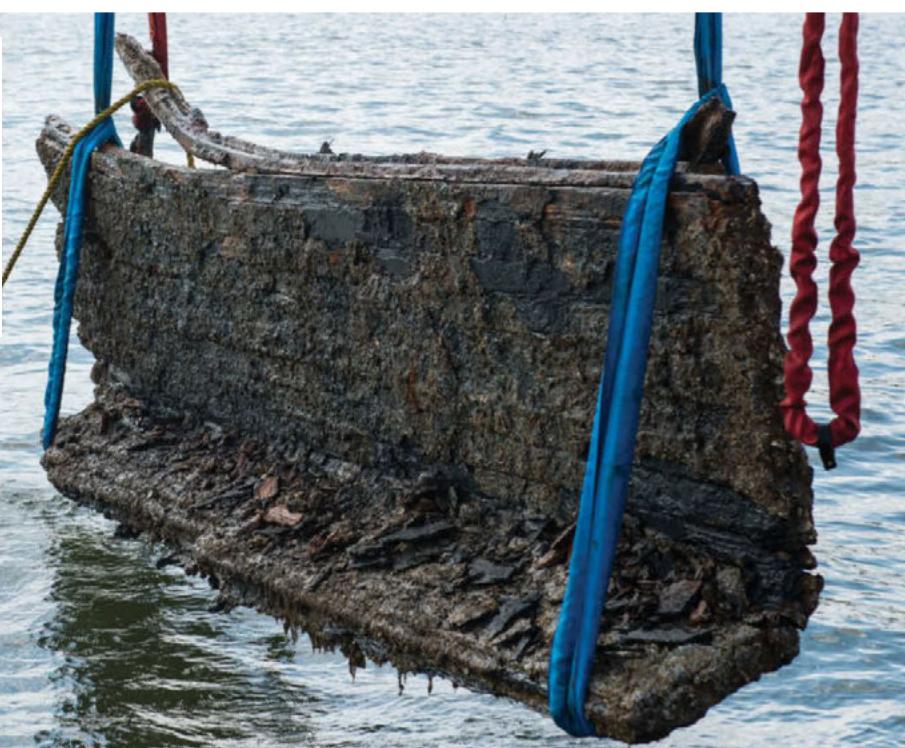
The casemate ironclad design put thick iron sheathing atop layers of wood, but the materials and how they were fastened weren't definitively known for *Georgia*. Some answers came from a large portion of the southern end of the ship, which was raised by crane in five-ton increments after a large guillotine-type blade and underwater power tools were used to break it up. The pieces confirmed what was known from documentary accounts, that *Georgia*'s builders shielded it with railroad-track iron. Archaeologists then learned not only that

the iron was attached to its wooden backing by six- to eight-inch-long spikes and two-foot bolt-type fasteners, but also that some of the wood had actually survived. "Everything we could reach from the sides of the casemate indicated the wood has *Teredo navalis*, or shipworm, rot," Watts says, "but under the casemate there is surviving wood structure, which is great." The wood they observed differed from what they expected based on historical records, he adds. The first look at *Georgia*'s wood shows mostly pine, indicating the Confederacy's need to make do with limited materials. "While they planned to have two layers of pine covered by oak, they were probably running out of material and had to use pine on all three layers in some places," he explains. "Some of the oak fastened to the railroad iron was not up to spec. They frequently used what they had, instead of what was specified."

The presence of that wood was a welcome surprise, but it



Lacking a supply of iron sheathing, workers in occupied Savannah instead used railroad iron for the ship's armor, or casemate, shown here (above) in a cross-section. Larger sections of the casemate (right) are telling archaeologists and historians much about the unusual construction of the ship.



also made raising most of the ship's structure, including the massive surviving portion of the western section consisting of iron and saturated wood, too difficult or time-consuming. As a wreck, *Georgia* is monstrously heavy just as it was when it went down in 1864. That weight and several design flaws likely kept the ironclad from being anything more than just a gun battery sitting at the waterline.

In July 2015, Navy divers helped raise one of *Georgia*'s two propellers. Its partner was not found, but the single, screw-driven, three-blade propeller helps explain why the ironclad stayed put—the propeller may simply have been too small to move the ship, especially in the river's strong currents. There also probably wasn't a lot of oomph behind those propellers, as it



Many of the 170 projectiles raised from *Georgia* were still live and potentially dangerous. Specialists in unexploded ordnance stored them in water before rendering them inert.

is known that one of *Georgia*'s two steam engines was used exclusively to run a pump that kept it from taking on water and sinking. "The engine cylinders that we have identified so far have been small," says Watts. "We've not recovered everything we should have to fully reconstruct the steam machinery, but we can tell that it is small, geared for a slower-turning propeller. It may be that that was all that was available at the time."

The recovery effort has also brought up all the cannons listed on the ship's manifest. In addition to the two raised in

1986, five more were retrieved, including two Dahlgrens, the distinctive rounded type used in the Civil War. There were 170 projectiles, many of them still live and potentially dangerous. It took specialists two months to render the ammunition inert by placing them in special water tanks, using a remote drill, and then chemically neutralizing the powder inside. In addition, X-shaped

metal pieces, known as "eyes for tackle" were found, and had been used for positioning a pivoting gun carriage. Customarily such items would have been made of brass, a stable metal, but the *Georgia* yielded one made from iron—prone to rust—indicating yet another suboptimal substitution. An especially rare type of lock mechanism and a fuse for a torpedo were also found, "like nothing any of us have ever seen," says Watts.

This metal piece from *Georgia*, called an "eye for tackle," would have been used for positioning a gun carriage.



Despite its limitations as a warship—as any kind of ship at all, actually—Confederate sailors manned *Georgia* consistently for the better part of two years. The excavation has begun to provide a picture of improvisatory wartime life aboard *Georgia*. Divers excavated the brass handle of a Union artillery short sword that found its way into Confederate hands. "They captured supplies, and used them as they saw fit," says Jim Jobling, a conservator at Texas A&M. There was also a brass key—with no chest to open—a tourniquet press from a surgeon's kit, and several buttons, including two likely dating to the Revolutionary War. During the last phase of the excavation, when silt was scooped up onto the barge, many personal items appeared, including a spoon, glass marbles, and intact glass bottles. "It really is amazing to me," Morgan says, to find so many small, personal items after decades of disturbance in an active estuary.

WHILE THE 2015 SEASON wasn't the first excavation of *Georgia*, it might be the last. The first phase of harbor deepening began in earnest in September 2015, and decisions about the remaining underwater sections of *Georgia*'s armor will be made as the harbor project nears *Georgia*'s resting place. "Until we have a full picture of the casemate remains, we don't know that much more about how it was constructed," says Morgan, who is cautious about making grand conclusions based on the portions raised so far. "We're getting large timbers, some railroad iron, but we're trying to keep it together and reconstruct the vessel. It will take recovery and seeing the pieces out of the water to do that." Some of the railroad iron is being stored in the river, and the conservation lab at Texas A&M has years of conservation and treatment ahead of it.

"The more we find, the more questions we have," Morgan adds. "There's a lot that is still a mystery. *Georgia* is slowly revealing itself to us, but it will take a while to piece it all together." ■

Marion Blackburn is a writer based in Greenville, North Carolina.

Using thousands of digital images, archaeologist Phil Sapirstein created this highly detailed and extremely accurate 3-D model of the temple of Hera, or the Heraion, at the site of Olympia.



A New View of the Birthplace of the Olympics

FOR A VARIETY OF FIELD projects over the last decade, archaeologist Phil Sapirstein has lugged more than 20 pounds of high-tech laser imaging equipment around the Mediterranean gathering data to create 3-D models of ancient monuments.

"I have been working on architectural history for quite a while," says Sapirstein, who teaches at University of Nebraska-Lincoln, "and one of my main focuses has been the general problem of the origin of architectural styles, especially the Doric style, in the Archaic period [ca. 700–480 B.C.]."

More often than not, little remains of Archaic buildings. The mid-seventh-century B.C. Old Temple at Corinth, dedicated to the god Apollo, burned down and was replaced, obliterating most evidence of the original building. Other structures from the period were flawed due to the lack of experience with engineering and construction techniques needed for monumental stone architecture. The early temple of Hera on the island of Samos, for instance, which Sapirstein characterizes as an "experimental building," didn't survive because it subsided into the marshy land on which it was built. Further complicating the effort to identify these early buildings, the stone was often reused, obscuring its original context.

What does frequently survive, however, are the temples' ceramic roof tiles. Sapirstein realized that these tiles, which are relatively abundant, were an underutilized source of information, especially when examined using 3-D imagery. "I started working with 3-D modeling software early on because you often have to reconstruct the roofing system from very tiny fragments," explains Sapirstein. "With this software, I could see what the roofs actually would have looked like and how they



Taking an innovative approach to one of ancient architecture's most intriguing questions

by JARRETT A. LOBELL

functioned. It worked great.” But Sapirstein knew the technology was impractical, if not impossible, for most archaeologists to use. “You have to acquire a scanner, which takes some doing, and it’s really expensive,” he says. “You then have to know how to use it and how to process the models. It’s a huge investment.” Sapirstein wanted to find an alternative method—and for this he returned to one of the temples that started it all.

THE TEMPLE OF HERA at Olympia, or the Heraion, dates to around 600 B.C. and is one of the oldest surviving Greek stone Doric temples. In his *Description of Greece*, the second-century A.D. traveler Pausanias describes legendary events that, along with actual stylistic attributes of the Heraion, led Wilhelm Dörpfeld—a German archaeologist working in the late nineteenth and early twentieth centuries,

and the scholar most closely associated with the structure—to date the original building to 1096 B.C. However, while there is evidence of ritual activity at Olympia dating back to the eleventh century B.C., there were no permanent large structures at this early date. And even when the Olympics first took place, probably well after the traditional date of 776 B.C., there were likely no sizeable buildings at the site.

Located in the north part of the Altis, Olympia’s sacred precinct, the Heraion is probably the site’s first monumental stone building. Dörpfeld dug trenches under the temple and found two structures he interpreted as predecessors. But scholars today no longer believe there were in fact any previous buildings on this spot, and that what Dörpfeld had actually uncovered was the Heraion’s foundation. “The Heraion is actually very well preserved,” says Sapirstein, “and doesn’t



The Heraion dates to about 600 B.C. and was likely the first monumental building in Olympia, one of the most important religious centers in Greece.

appear to have been significantly altered or renovated after its construction, despite its thousand-year history of use. It's one of the very few of these early buildings we can date from stratigraphic and not just stylistic evidence." The temple is also the first well-preserved peripteral Doric temple—that is, having columns completely surrounding it. "This is an important moment in Greek architecture," says Sapirstein. "The fact that the Heraion's columns are made of stone, which is expensive and labor intensive, signifies a major expansion of the investment the Greeks put into building a monumental structure."

What is equally as significant as the existence of the stone columns is the long-accepted narrative about them. "The big story about the Heraion is that its columns were originally made of wood and gradually replaced with stone," explains Sapirstein. "This fits with the time-honored idea that the Doric order was first developed in wood." The concept of the wooden columns is mostly drawn not from archaeological evidence, but from Dörpfeld. Dörpfeld was a stalwart supporter of what is termed tectonic theory, an idea developed in the mid-nineteenth century that in ancient architecture form follows function. For Dörpfeld this meant that the Heraion would not have evolved in stone the way it did if it had not been conceived of and made from wood—that is, the function of the original elements determined how they would appear in wood, and thus how the same elements would appear in stone.

Architectural historians of the time could draw on the works of the Roman architect Vitruvius and his *De Architectura*, 10 books on architectural history written at the end of the first century B.C. Vitruvius believed that certain architectural elements of the entablature—the lintel of a classical building that

is supported by the columns or walls—of Doric stone buildings had evolved from wooden prototypes, as had decorative elements, such as mutules, guttae, and triglyphs. The theory of the wooden origins of the Doric order became the prevailing one.

Because the sizes of the Heraion's columns vary—some are composed of distinct drums (the individual sections that make up the shaft of a column) stacked atop one another, while others are monolithic—and because many of its capitals are of different styles and belong to different time periods, Dörpfeld theorized that as the original wooden columns decayed, they were replaced with stone ones. Nineteenth-century archaeologists conjectured that little would be found of early Greek monumental architecture because it all would have disappeared and been replaced by stone—a useful explanation for why none of these wooden architectural elements did, in fact, survive. "The temple of Hera at Olympia provided the best example of an older wooden Doric architecture in the midst of the hypothesized conversion to stone," says Sapirstein.

INSPIRED BY A LONG-STANDING interest in the Heraion, which had not been comprehensively reexamined since Dörpfeld's publication of his work on the temple nearly a century ago, and with the success of his 3-D models in mind, Sapirstein decided it was time to take another look. "Early on in my research I saw some evidence that the Heraion's stone columns were mostly original to the building and that the model of the wood-turned-stone columns was actually pretty dubious," Sapirstein says. "But I didn't have the time or the technology to support this new idea, and because it's one that's been ensconced for 120 years, if you want to undermine it, you better have your ducks in a row." Sapirstein knew that he didn't want to take the traditional approach and spend the next two decades recording, measuring, and drawing each of the temple's extant stone fragments. He also knew that laser scanning was probably out of the question. "I liked the idea of looking at the Heraion again, but laser-scanning the whole monument, while feasible, wouldn't give me the kind of data I needed for the restudy," he says. "In the meantime, the technology of photogrammetry had become a powerful alternative, so I thought I would give it a shot, even though the technique hadn't yet been attempted at such a large site at the level of detail I needed."

Photogrammetry, the science of using photographs to make measurements, has its roots in the nineteenth century. At the time, balloon-mounted cameras were used, for example, to survey the city of Paris, and a Prussian architect named Albrecht Meydenbauer built special cameras that allowed him



to shoot from the ground and use the measurements to survey inaccessible features such as church spires in Germany that had never been drawn accurately before. Digital photogrammetry takes the same basic approach. Thanks to the power of inexpensive modern computers, with their large memory and storage capacity, it's now possible to use this computationally intensive approach—for the Heraion, Sapirstein used 4,350 unique images taken from different vantage points—to create 3-D models of specific features or entire buildings. "All of a sudden you don't need a 3-D scanner," says Sapirstein, "just a decent digital camera, some software, and a little time." Over the course of five days, Sapirstein recorded the entire Heraion—a building measuring 165 feet long by 62 feet wide—at one millimeter resolution with plus or minus one millimeter of accuracy, providing a tremendous level of detail and precision. "It takes a bit to learn how to take the photos, use the software, and control for error, but once you've figured it out, photogrammetry is highly effective, cheap, and visually appealing," Sapirstein says.

The 3-D models produced by photogrammetry make possible virtual reconstructions of buildings that can never be rebuilt either because they are too fragile or because too many pieces are missing. There are more than 100 stone fragments and fallen column drums belonging to the Heraion, none of which would likely ever be rejoined to the building. Sapirstein explains, "There are drums missing, which would mean that some would have to 'float.' With these models, we can place them, virtually, in their correct locations. I even have a few columns that I can digitally reconstruct based on fragments lying on the ground. I can completely restore something that isn't even there." Anastylosis—reconstructing a building using its original elements as much as possible—is an inestimably valuable tool, and this digital version no less so. The technology allows scholars to test hypothetical placements of fragments, and to correct them if they seem wrong. "This would be extremely difficult to do with a block of stone that weighs several tons," says Sapirstein. But while photogrammetry was invaluable in creating these 3-D digital models, would they advance Sapirstein's theory that the Heraion's original columns had, in fact, not been made of wood, but rather had always been stone?

One of the main pieces of evidence cited to support the idea that the Doric order evolved from wooden origins is the crescent-shaped cuttings in the stylobate, the platform on which the columns sit. These cuttings were believed to have been used to facilitate the raising of wooden, rather than stone, columns. This theory, which has gone largely unquestioned for more than 80 years, has rested on century-old drawings of the Heraion's

early excavations. While cleaning the area of the stylobate where six of the columns are missing, Sapirstein realized that the cuttings actually didn't have to have anything to do with moving wooden columns at all. "I had a eureka moment," he says, "and it occurred to me that these crescent-shaped slots might actually be associated with lifting monolithic stone column shafts and not necessarily wooden ones. This would mean that none of the peristyle would ever have been wood. The 3-D recording was essential for revealing how all of this would have worked."

TIMING AND TECHNOLOGY always have and always will influence interpretation. When he visited Olympia more than 700 years after the temple was built, Pausanias saw what he describes as a "pillar of oak." Scholars have long wondered what he actually saw, and what it might mean about the building's history: Was it an original column located in the interior and thus not exposed to rot as the exterior peristyle columns would have been? Was he describing a repair made during the Roman period? Or was the wooden column one of the treasured remnants of the sacred site's even-more-ancient past stored in the temple for safekeeping? Pausanias doesn't tell his readers more.

At the time Dörpfeld was working on the Heraion, there was little scholarly interest in or understanding of early Greek architecture. Few buildings had been excavated or even identified as being "early." In fact, there was no consensus about how to even date monuments, whether through stratigraphy, pottery sequences, or any other system, explains Sapirstein. "Dörpfeld was right there when the temple of Hera was excavated, and he suspected that it was very early, but the methodology of how to establish this just wasn't around yet. With the Heraion being the only one of its kind, he didn't have anything to compare it to," he says, "so he came up with a theory that, at the time and for more than a century, explained a great deal."

For Sapirstein, technology that wasn't available even 10 years ago has allowed him to suggest a fresh interpretation of the Heraion in particular, and, indeed, of Greek architecture in general. "This raises the question of the validity of the tectonic theory," says Sapirstein. "I believe it demands that we rethink in a fundamental way how the Doric order developed. In the past, the remains have been interpreted to fit the theory, rather than vice-versa. I'd like to start again with the evidence." ■

Jarrett A. Lobell is executive editor at ARCHAEOLOGY. For more images of Sapirstein's work, go to archaeology.org/olympia.

This elevation view of the south side of the Heraion's peristyle shows the temple's in situ columns, two of which were rebuilt in the 20th century, as well as the column drums and capitals that Sapirstein has been able to reassign to their original positions.



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LETTER FROM ROTTERDAM

During the construction of the Markthal, a massive covered market in the center of futuristic downtown Rotterdam, archaeologists discovered a series of structures dating back to before the city's founding in A.D. 1270.



The City and the Sea

How a small Dutch village became Europe's greatest port

by HEATHER TUCKER

The skyscrapers of Rotterdam rise high above the banks of the Nieuwe Maas, a channel of the Rhine Delta, whose rivers snake their way across most of the southern Netherlands. Lying some 20 miles upstream from the North Sea, the city's port is a vital trading center that connects the industrial heartland of Europe with the rest of the world. In this forward-looking, modern metropolis, the country's second largest, almost no two buildings look alike, and its futuristic appearance is a stark contrast to more traditional Dutch cities, such as Amsterdam or

Delft. Rotterdam's Centraal train station, for example, is all angles and sharp lines with a tip that points new arrivals in the direction of the city center. The public library is covered in creeping yellow tubes, while the nearby flying saucer of the Blaak metro station seems poised for take-off. The city's newest architectural marvel is the Markthal, a massive covered market hall in the shape of an upended horseshoe that stands near the fifteenth-century St. Lawrence Church. Extensive excavations here have revealed that the hypermodern Markthal lies above what was once

the very heart of medieval Rotterdam. "The St. Lawrence Church is the only medieval remnant you can see," says Arnold Carmiggelt, chief of Rotterdam's archaeological bureau. "The only other medieval structures are underground."

The reason so little of medieval Rotterdam survives is that on May 14, 1940, the German Luftwaffe carried out a devastating raid on the city. That attack and the ensuing fire left only a handful of buildings still standing. The redevelopment of Rotterdam and its port after World War II took decades, and while its citi-



At the lowest level of the Markthal excavations (above), dating to between A.D. 950 and 1050, an archaeologist measures a wicker wall, part of a farmhouse. An enigmatic trident-shaped artifact (right) was also discovered among the remains.

zens built for the future, they found themselves constantly encountering their city's history. "As people were cleaning up, and later when rebuilding, they would find items from the past—tiles, earthenware, medieval and postmedieval artifacts, as well as locks and sluices," says Carmiggelt. "Because everything had been lost, they were very interested in these objects from the past." The city's archaeological bureau, the Netherlands' first such municipal agency, was founded in 1960 primarily

because there were so many accidental historical discoveries.

When construction on the Markthal began in 2009, the bureau was faced with both its biggest opportunity and its toughest challenge. Officials knew the structure's planned four-level underground garage would destroy any archaeological remains that lay in its way. Excavating ahead of the structure meant digging to



a depth of 40 feet, well below sea level. "Constantly seeping groundwater would make archaeological work impossible," Carmiggelt says, "so we worked with geotechnicians to make a system to keep water out of the excavation." Working on a tight deadline through winters, in harsh conditions, the team made a series of discoveries that peeled back the history of Rotterdam to the time of the city's founding and even earlier. The waterlogged earth that made excavation difficult meant that the wooden structures and many artifacts found in garbage layers and cesspits, never exposed to oxygen, were extremely well preserved. They provided remarkably clear evidence of how the earliest generations of Rotterdammers struggled to coexist with the same sea that would eventually enable a small, wet settlement of a handful of farmers to grow into a bustling medieval center, and eventually into one of the world's most consequential cities, with the largest port in Europe.

Some of the earliest known inhabitants of what became Rotterdam lived during the Roman period, when the southern Netherlands were part of the frontier province of Germania Inferior. They made their homes on marshy peatland near a fort that stood alongside the riverbank of the Old Rhine, the northern border of the Roman Empire. In addition to Roman-era ceramics found at the very bottom of the Markthal excavations, city archaeologists also discovered wooden locks,

trenches, and ditches that were all used in attempts to control water levels even then. After the Romans withdrew from the area in the second half of the third century A.D., the population steeply declined, in part because

rising sea levels eventually made the region uninhabitable.

It wasn't until A.D. 900 that the first pioneering farmers returned to the riverbanks of what was by then known as the Rotte (meaning "muddy water") River. A farmstead is first mentioned in a charter dating to 1028, which describes a church of Rotta (a Latinization of "Rotte") that belonged to Hohorst Monastery, which in turn was part of the vast Germanic Holy Roman Empire. To the surprise of the city archaeologists, they found extensive remains dating to this period during the Markthal excavations. At a depth of some 33 feet they encountered a well-preserved *terp*, or a raised earthen mound, on which they found the remains of six distinct farmsteads dating from 950 to 1050.

In the *terp*'s trash heaps archaeologists discovered a wealth of plant remains, mainly oats, barley, and emmer wheat, that offer a look at what the Rotta farmers cultivated. They also found fragments of hand-operated mills—used to grind the grain—that were made from tephrite, a volcanic rock from Germany's western Eifel region, roughly 200 miles away. Animal bones from cattle, sheep, goats, pigs, small chickens, and geese suggest the variety of animals the people of Rotta raised. The farmers appear to have lived with their livestock in A-frame buildings that had wicker woven walls strengthened with clay and sloped reed roofs. Soil samples taken from inside one of the houses on the Rotta *terp* showed a high amount of nitrate, a byproduct of fecal material, in one section, which was likely the house's indoor "barnyard."

In one of the garbage layers of the *terp*, the team found a small bone object with three points, resembling a trident. They were puzzled by the find, which is the first of its kind to be excavated. "We didn't know what it did," says city archaeologist Marjolein van den Dries. "So Leiden University made replicas of the item



Tin-alloy pilgrim badges, such as these depicting the discovery of a statue of the Virgin Mary (top) and St. John the Baptist (above), were discovered in the late medieval sections of the site.

and then tried many different simulations on various materials." Using a microscope, archaeologists compared traces of use-wear on the replicas to that on the original. The experimental research showed that the "trident" was used in wool processing, which also must have been an important activity in the Rotta farmstead.

While they may have enjoyed some success in farming and raising livestock, life for the residents of the humble Rotta village was difficult. Despite building their farms on the



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elevated banks of the river, the villagers were constantly threatened by flooding. The farmers tried to combat the rising water by draining the peat via small man-made canals, which are still visible in the archaeological record. But because peat settles much more than other soil types, when the land was drained, it lowered in elevation. In an area already prone to flooding, this only made the problem worse. "Their very way of life made it impossible to live there," says van den Dries. Unable to overcome the wet conditions and frequent flooding, the Rotta villagers were forced to abandon their homes around 1050.

During the Middle Ages, local nobles with holdings along the Rotte constructed a series of protective walls to guard their own lands against flooding. But these individual dikes only resulted in raising the water levels along other sections of the river. Eventually, in 1270, the Count of Holland, Floris V, ordered the construction of a single sea wall to protect the region against floods. The resulting dike measured 1,300 feet long, 23 feet wide, and nearly five feet high, and was constructed across the river not far from the old Rotta village.

Above the remains of the abandoned Rotta farmstead, extensive traces of Rotterdam, the town created in the wake of the dike's construction, were discovered by city archaeologists. Its proximity to the river Rotte and the North Sea was now not just a hardship to overcome, but had become a key to the local economy. The Rotte, in addition to functioning as a drainage system, became a trade route linking Antwerp, Bruges, England, France, and the Baltic region. Because the dike blocked direct passage through the Rotte, traders had to reload their goods on the other side or temporarily store them in Rotterdam, which turned the town into an important port (and market) for staple goods, such as beer and textiles, the latter linked to leaden textile seals that were found in the Markthal excavations. Many Rotterdammers also became involved in the burgeoning fishing industry. Rotterdam would become the most important city for herring in the region, with a fleet of 151 herring ships sailing out of its port by 1603. New techniques, such as herring curing, allowed for bigger catches, faster processing, and longer storage. A number of artifacts related to the fishing trade—fishing hooks, net weights, and needles for produc-

ing and mending nets—were found at the Markthal site.

Rotterdam began to grow quickly after it received a city charter in 1340 from Count Willem IV of Holland. This official recognition gave the city the right to dig a deeper shipping canal, creating a trading link with other Dutch cities, allowing it to become a local transshipment center connecting it with England and Germany. By 1358, Rotterdammers built new fortifications around the city. They expanded the dike in the middle of the fourteenth century until it measured 70 feet wide and nine feet high. A city seal, found in a layer dating to around 1400, depicts the importance of the river and the dike to the growing port. Made of wax and found in a copper box, it bears a vertical bar, which represents the river, coming to an abrupt stop where it meets a horizontal bar representing the dike.

Around this time Rotterdam's officials created two polders, or areas of low-lying reclaimed land enclosed by dikes, to accommodate the growing population. "These were medieval housing projects," says historian Jan van den Noort, "that consisted of

(continued on page 62)



A number of ceramic vessels made in foreign countries, such as a piece (left) from Pingsdorf, Germany, were unearthed at the site. A ceramic oil lamp (right) was made with two holes through which a cord could have been drawn and used to suspend the lamp from the ceiling.

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Materials for the Nov/Dec issue
are due on September 15, 2016



(continued from page 58)

houses and workshops." The eastern section of Westnieuwland, one of the two polders, was where the Markthal now stands.

The excavations offered a remarkable picture of the evolution of houses built in the Westnieuwland polder. In the earlier levels, city archaeologists found the remains of wood houses roofed with thatch and fireplaces located in the center of the houses, while in the fifteenth-century sections of the site it is evident that houses were being built out of stone. Rotterdammers were becoming more prosperous and strove to meet city regulations that attempted to prevent large fires. This shift in construction materials also touched off a change in the kind of modest household items that were found in houses. For example, oil lamps unearthed at the site had two holes before the fifteenth century. A fire hazard if placed too near the wooden walls, the lamps were suspended from the ceiling by a cord strung through the two holes. Once stone came into use, lamps could be safely hung on walls, and only one hole was needed to secure them. Another testament to Rotterdammers' preoccupation with fire is numerous examples of flat unglazed earthenware objects—medieval fire extinguishers—used to prevent embers from rekindling. By 1500, the threat of fire had been reduced to such a degree that houses were being built close together.

While construction of new houses on the Westnieuwland polder

Two Portuguese oil jugs (top) and a bottle that once held mineral water from the German town of Selters (right), all date to the eighteenth century, by which time Rotterdam had become almost completely reliant on imported goods.

speaks to the city's growing wealth, the trash pits behind them held evidence of the new importance of trading in the city's life. Tin-alloy pilgrims' insignias from foreign lands—Germany, England, Italy, France, and Belgium—suggest that international travel was becoming more commonplace. Also testifying to the city's growing cosmopolitanism were the discoveries of minute quantities of fruits and spices such as olives, pomegranates, and pepper from the Mediterranean, Africa, and

Asia, as well as ceramics from Spain. By 1556, Rotterdam was subsumed by the Spanish Empire, which placed a high value on its strategic location at the entrance to the Rhine Delta. Even as it continued to be an important trading center, the city was poised to play a more important role on the world stage.

The year 1572 was pivotal for Rotterdammers. After Spanish soldiers killed two important locals, the city switched its allegiance from the Spanish Empire to the newly independent nation of Holland, then led by Willem van Oranje. Willem threw his support behind the city, building new fortifications and creating an inner harbor, which gave city merchants fresh opportunities to expand trade and shipping. In 1585, the Spanish King Phillip II forbade all commerce between the areas he ruled and the Netherlands. Refugee merchants fleeing Spanish-held Antwerp began to use Rotterdam to trade with overseas territories, and this, combined with growing trade with the Far East, meant Rotterdam became an even more important port.





Today, visitors can ride down escalators that allow them to descend beneath the Markthal where artifacts from the dig are displayed at the depths where archaeologists found them.

being imported from outside the city, which was by then focused almost exclusively on trade. By the eighteenth century, Rotterdam was even importing water in stoneware jugs, like one found during the excavations from Selters, a German town known for its high-quality mineral water. Still other finds from this period speaking to the city's growing reliance on trade are two-eared jugs from Portugal. These jugs most likely were originally produced to transport olive oil, but in northwest Europe these jars have only been found in shipwrecks or harbor cities, probably taken home as personal belongings by the sailors who were becoming so important to Rotterdam's economy.

Few artifacts or structures in the Markthal excavations that date to after the seventeenth century were discovered. But by that time, the historical record amply shows that the city was well on its way to becoming one of the most vital harbors in the world. Today the Port of Rotterdam stretches more than 25 miles in length and covers 41 square miles. Each year, some 30,000 seagoing vessels and 110,000 inland vessels sail in and out of Rotterdam, which handles some 465 million tons in cargo, making it by far Europe's busiest port.

Inside the Markthal, gigantic and colorful fruits, vegetables, and even whole fish appear to rain down from the ceiling. Known as the *Horn of Plenty*, this photographic 3-D illusion, one of the largest art pieces in the Netherlands, refers to the great still-life cornucopias painted during the Dutch Golden Age in the seventeenth century. Below this vast celebration of the country's past is an easily overlooked set of escalators, dubbed the Time Stairs. What could have been solely a method of returning to one's car is actually a means of descending through Rotterdam's historical eras. Near the escalators, artifacts from each occupation layer are displayed in small glass rooms on the floor closest to where they were discovered and excavated. At the very bottom of the escalators, some 50 feet below the Markthal, visitors reach the oldest part of the site, the end of their trip through time. The items here are small and sparse—a key, a knife blade, a pair of shears, a pile of animal bones. They are a reminder that a city that is now called "Europe's gateway to the world" was once a simple village struggling against the sea for its very survival. ■

Heather Tucker is a freelance writer based in Rotterdam.

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Dispatches from the AIA

www.archaeological.org

EXCAVATE, EDUCATE, ADVOCATE

AIA Site Preservation Included in List of Best Preservation Ideas from Around the World

AN ESSAY DESCRIBING the AIA's approach to archaeological site preservation was selected as one of eight that will be used by the U.S. Advisory Council on Historic Preservation (AChP) to develop policy recommendations for the next presidential administration and Congress. The AIA essay was one of almost three dozen entries in a competition sponsored by the U.S. National Committee of the International Council on Monuments and Sites (US/ICOMOS) and the AChP to "identify useful approaches to heritage law, policy, program strategy, and related preservation challenges from around the world that could help point the way to innovations in U.S. heritage practice over the next 50 years." The winning essays will be published in a book called *With a World of Heritage So Rich: Lessons from Across the Globe for U.S. Historic Preservation in Its Second 50 Years*.

The competition, held on the fiftieth anniversary of the 1966 National Historic Preservation Act (NHPA), asked the question, "What can and should U.S. preservation law and federal programs look like for the next 50 years?" Entrants were asked to consider several major themes, including preservation as a tool for sustainable development, the challenges of climate change adaptation and resilience, democratizing preservation, promoting inclusiveness, rethinking established preservation processes and systems, and community-based valuation of heritage resources.

The paradigm adopted in 2009 by the AIA for its Site Preservation



Adopting Narce, a project in Italy funded by the AIA Site Preservation Program, created a local volunteer group to clean and maintain the site, install new signage, and work with archaeologists to create exhibits for the local museum. The project, typical of AIA-supported projects, combines site preservation with community engagement and outreach.

Program addresses many of these issues listed by US/ICOMOS and the AChP. The AIA's approach to site preservation is predicated on the idea that material conservation is not enough to ensure long-term site preservation and that the future of preservation lies in more holistic initiatives that use a portion of the funds for direct

conservation and the rest to implement community-focused, site-specific preservation initiatives, including outreach, education, specialized training, and economic development. Under the guidelines of the revised program, the AIA has funded 29 projects on five continents, many of which have been featured in "Dispatches from the AIA."

To learn more about the AIA program, visit www.archaeological.org/sitepreservation. You can read more about the *With a World of Heritage so Rich* project at www.usicomas.org.

AIA-Boston Society Supports “Eating Archaeology”

WHAT DO A PRECOLONIAL Aztec chocolate drink, a nineteenth-century American sponge cake, a Mycenaean lamb stew, and a Bronze Age Chinese pork dish have in common? They were all featured at a unique outreach event sponsored by the AIA-Boston Society in collaboration with Boston University’s archaeology, gastronomy, and culinary arts departments.

The AIA-Boston Society received an outreach grant for “Eating Archaeology,” a multidisciplinary event that challenged four teams of graduate students in archaeology, culinary arts, and food history to research and recreate ancient recipes from as long ago as the Greek Bronze Age to as recently as the American colonial period. Each team took on one culture and era—Bronze Age Greece, Bronze Age China, pre-Columbian Mesoamerica, and nineteenth-century America. Months of research and planning culminated in a day of presentations and tastings attended by more than 100 people.

Creative programs such as the one sponsored by the AIA-Boston Society bridge the gap between the academic community and the general public in new and engaging ways. Each year the AIA provides grants to AIA Local Societies to support community outreach programs. Grants are made twice a year, in the spring and fall. Other winning projects from the past year include:

- ♦ **Central Arizona:** Apples + Archaeology matches volunteer speakers with educators in the Phoenix area who request school visits.

- ♦ **Charlottesville, Virginia:** UN-earthED, a collaborative public sculpture and archaeological outreach project of the University of Virginia (UVA)’s Interdisciplinary Program in Archaeology and the Studio and Art History Programs, has built a replica archaeological site within the property of Baker Butler Elementary School in Charlottesville. In October, the school’s fifth-grade students will begin to excavate the site with the assistance of UVA archaeology students. The excavation will recur annually until the mound is thoroughly excavated and the site completely revealed.

- ♦ **Greensboro, North Carolina:** For the AIA-Greensboro Society’s Archaeology in the Triad event, five archaeologists from local universities will present their work in consecutive 10-minute presentations.

- ♦ **Jacksonville, Florida:** The AIA-Jacksonville Society will put together a portable multimedia presentation that includes posters, a slide show, power point, photo array, and artifact display that will be taken by Jacksonville Society members to various venues in the community, including schools and retirement centers.

- ♦ **Minneapolis/St. Paul, Minnesota:** In celebration of International Archaeology Day and the fiftieth anniversary of the establishment of the National Historic Preservation Act, the AIA-Minneapolis/St. Paul Society will present an informal panel discussion about the preservation of cultural heritage, along with a poster session of student work related to archaeology and preservation.

- ♦ **Orange County, California:** An outreach grant was used to invite more than a thousand ARCHAEOLOGY magazine subscribers to a program that featured three prominent archaeologists discussing their latest work. The Society used the event to encourage magazine subscribers to become Society-level members.

- ♦ **Richmond, Virginia:** The Richmond

Society will partner with the Science Museum of Virginia and RVA Archaeology to host an archaeology fair on International Archaeology Day that will include a focus on archaeological sites in the Richmond area, such as Lumpkin’s Jail and Hanover Tavern.

- ♦ **Spokane, Washington:** The Spokane Society, in partnership with Gonzaga University, will host a troupe of Roman military reenactors as part of a larger, semester-long focus on Roman life, religion, and history. The reenactment, to take place on Gonzaga’s quad, will be free and open to the public. Local sixth-graders, who study the ancient world as part of their social studies curriculum, will be encouraged to attend.

- ♦ **Staten Island, New York:** The Staten Island Society collaborated with the Archaeology Society of Staten Island and the Staten Island Museum to host a workshop series for high schools titled “Archaeology and Museums,” which discussed the role of archaeology and museums in preserving cultural heritage.

To learn more about becoming an AIA Society member, please visit www.archaeological.org/join. To upgrade from subscriber to Society member, go to [www.archaeological.org/upgrade](http://www.archaeological.org/).

AIA at EAA Annual Meeting

REPRESENTATIVES from the AIA will attend the 22nd Annual Meeting of the European Association of Archaeologists (EAA) in Vilnius, Lithuania, from August 30 to September 4, 2016. Participating in the EAA meeting offers the AIA an opportunity to strengthen its relationship with one of the leading archaeological organizations in Europe, foster and build connections with European colleagues, and present the Institute’s mission and activities to a wider audience. AIA’s Director of Programs, Ben Thomas, together with colleagues from Europe and Australia, is co-organizing

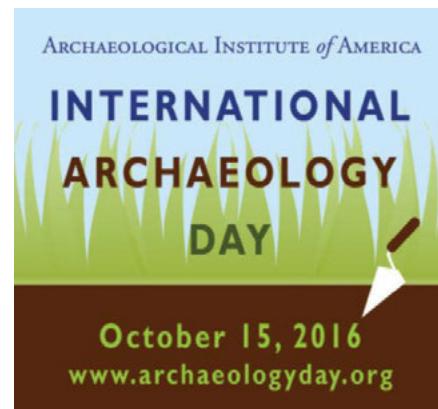
a session called “Visualizing the Past: Exploring Meaningful Approaches in Interpreting the Archaeological Record through Illustrations and Reconstructions,” during which he will present “Using Archaeological Reconstructions for Outreach and Community Engagement.” Thomas will also present a paper coauthored with AIA’s Senior Programs Coordinator, Meredith Langlitz, “Community Outreach and Engagement through Archaeology Fairs,” in the session “When Working with Many Partners: A Holistic Approach to Archaeological Research and Heritage Management.” In addition, the AIA will have a booth in the exhibit hall and will be represented at the meeting of the EAA Working

Party on Heritage and Tourism.

International Archaeology Day is October 15, 2016; NPS Is Official Sponsor

JOIN THE AIA FOR this annual celebration of archaeology, which is expanding every year—last year more than 100,000 people participated in International Archaeology Day (IAD) events around the world. The National Park Service (NPS) has

joined IAD as an official sponsor again this year, and will work with the AIA to promote IAD and NPS’s centennial. To read more about the program, visit www.archaeologyday.org.



AIA Announcements and Deadlines

121st Year of AIA Lecture Program Gets Under Way in September

AIA’s longest-running public outreach program will start its 121st season in September. Once again, almost 100 lecturers will present more than 200 lectures at AIA Local Societies across the United States and Canada. This extremely popular program allows attendees to hear about the latest discoveries and issues in archaeology directly from working archaeologists. For a full list of lectures and to find one near you, visit www.archaeological.org/lectures.

AIA-SCS Annual Meeting

The 118th AIA-SCS Joint Annual Meeting will take place in Toronto, Ontario, from January 5 to 8, 2017. Meeting information is available at www.archaeological.org/annualmeeting.

AIA Funding Deadlines

Each year the AIA offers fellowships and grants for travel, study, and publication to deserving scholars and students. To read more about the scholarships and grants and their application guidelines and requirements, visit www.archaeological.org/grants.

Site Preservation Grant to an inno-

vative project that uses outreach and community development alongside direct conservation to sustainably preserve archaeological sites. Deadline: October 15

Graduate Student Travel Award to assist graduate students presenting papers at the AIA Annual Meeting with their travel expenses. Deadline: October 30

Harriet and Leon Pomerance Fellowship to support a project relating to Aegean Bronze Age archaeology. Deadline: November 1

Helen M. Woodruff Fellowship of the AIA and the American Academy in Rome to support a Rome Prize Fellowship for the study of archaeology or classical studies. Deadline: November 1

Cotsen Excavation Grants to provide excavation support for professional AIA members working around the world. Deadline: November 1

John R. Coleman Traveling Fellowship to honor the memory of John R. Coleman by supporting travel and

study in Italy, the western Mediterranean, or North Africa. Deadline: November 1

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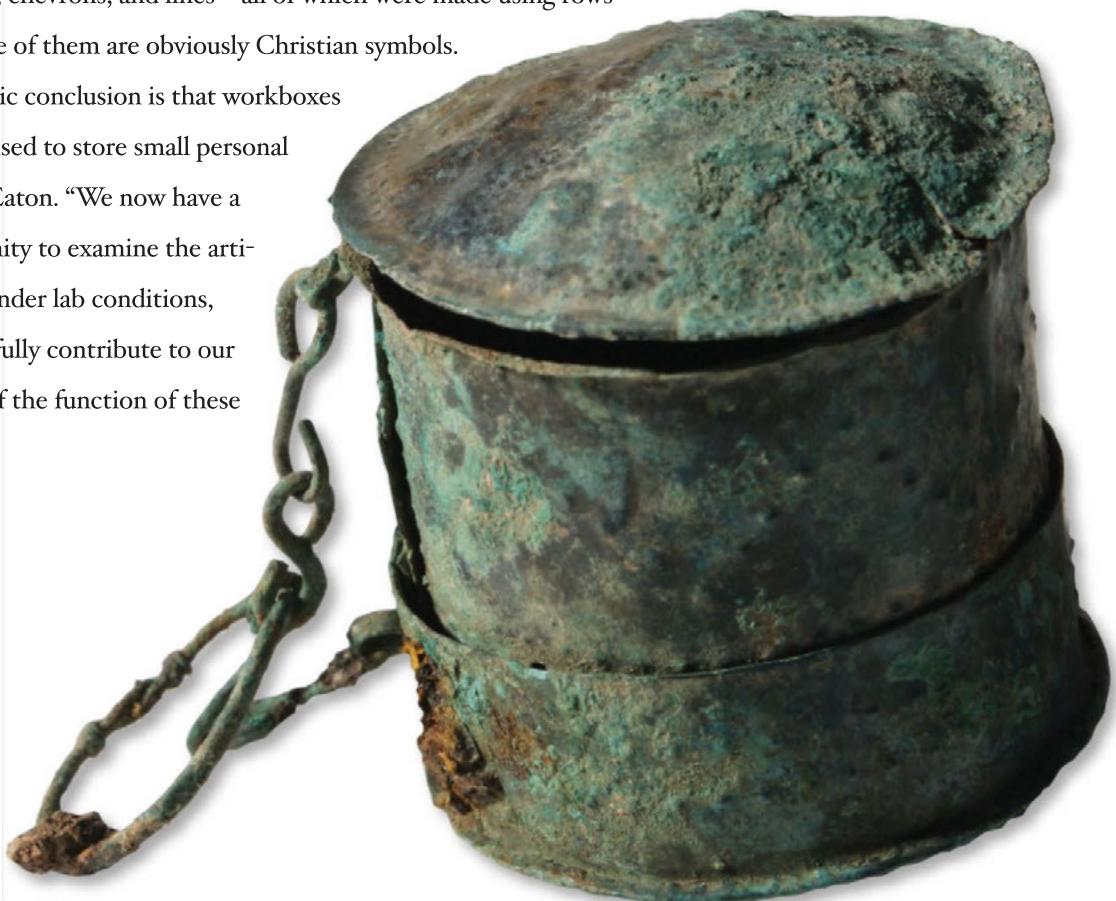
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ARTIFACT

Many people have keepsake boxes in which they safeguard personal items accumulated during their lives—a few faded family photos, a folded love letter from a summer romance, a single earring that was once part of a favorite pair. In a woman's grave in an Anglo-Saxon cemetery in Tidworth in southern England, archaeologists have discovered a copper alloy box that perhaps served a similar purpose, even after her death.

The small box is made of two cylinders that form the top and bottom and may have been soldered together. This type of container, sometimes called a “workbox,” has been found at sites across England, but only three have been uncovered in Wiltshire: one in the 1850s and one just two weeks before the example from Tidworth. “These recent finds are the first workboxes excavated in this region using scientific methodology,” says archaeologist and project manager Bruce Eaton of Wessex Archaeology. Because some workboxes have been found decorated with crosses, it has been suggested that they may have been Christian reliquaries. The Tidworth box is decorated on all of its surfaces with repoussé patterns—concentric rings, chevrons, and lines—all of which were made using rows of dots, but none of them are obviously Christian symbols.

A more prosaic conclusion is that workboxes may have been used to store small personal items, explains Eaton. “We now have a golden opportunity to examine the artifact’s contents under lab conditions, which will hopefully contribute to our understanding of the function of these types of boxes.”

**WHAT IS IT**

Workbox

CULTURE

Anglo-Saxon

DATE

Late 7th to early 8th century A.D.

MATERIAL

Copper alloy

FOUND

Tidworth, Wiltshire, England

DIMENSIONS

2.2 inches tall,
2.2 inches wide

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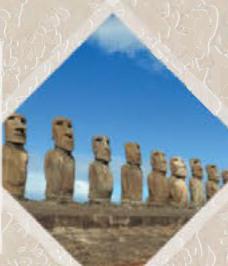
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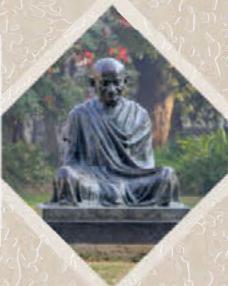
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