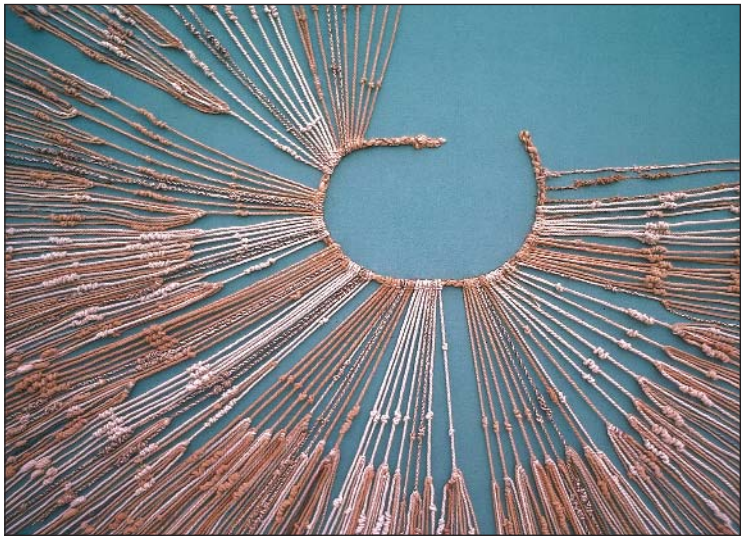
Cracking the Khipu Code

Researchers take a fresh look at Incan knotted strings and suggest that they may have been a written language, one that used a binary code to store information

In the late 16th century, Spanish travelers in central Peru ran into an old Indian man, probably a former official of the Incan empire, which Francisco Pizarro had conquered in 1532. The Spaniards saw the Indian try to hide something he was carrying, according to the account of one traveler, Diego Avalos y Figueroa, so they searched him and found several bunches of the cryptic knotted strings known as khipu. Many khipu simply recorded columns of numbers for accounting or census purposes, but the conquistadors believed that some contained historical narratives, religious myths, even poems. In this case, the Indian claimed that his khipu recorded everything the conquerors had done in the area, "both the good and evil." The leader of the Spanish party, Avalos y Figueroa reported, immediately "took and burned these accounts and punished the Indian" for having them.



Knotty problem. Scholars have decoded mathematical khipu, but the meaning of other sets of strings, perhaps recording narrative, remains a mystery.

But although the Spanish considered khipu dangerous, idolatrous objects and destroyed as many as they could, scholars have long dismissed the notion that khipu (or quipu, as the term is often spelled) were written documents. Instead, the strings were viewed as mnemonic devices—personalized memorization aids with no conventionalized signs—or, at most, as textile abacuses. The latter view gained support in 1923 when science historian L. Leland Locke proved that the 100 or so khipu at the American Museum of Natural History in New York City were used to store the results of calculations.

For these reasons the Inca have often been described as the only major Bronze Age civilization without a written language. In recent years, however, researchers have increasingly come to doubt this conclusion. Many now think that although khipu probably began as accounting tools, they had evolved into a writing system—a kind of three-dimensional binary code, unlike any other on Earth—by the time the Spanish arrived. "Most serious scholars of khipu today believe that they were more than mnemonic devices, and probably much more," says Galen Brokaw, an expert in ancient Andean texts at the State University of New York, Buffalo.

Yet the quest to understand khipu faces a serious obstacle: No one can read them. "Not a single narrative khipu has been convincingly deciphered," laments Harvard University anthropologist Gary Urton, who calls the situation "more than frustrating." And so Urton, spurred by new insights gained from textile experts, is now preparing the most sustained, intensive attack on the khipu code ever mounted. In a book to be released next month, *Signs of the Inka Khipu* (University of Texas Press), he has for the first time systematically broken down khipu into their constituent elements. He is using that breakdown to create a khipu database to help identify patterns in the arrangement of knots. Just as Maya studies exploded in the 1970s after researchers deciphered Maya hieroglyphs, Urton says, breaking the khipu code could be "an enormous potential source of insight" into the lives and minds of the still-mysterious Inca, who in the 16th century ruled the largest empire on Earth.

Binary code?

All known writing systems used for ordinary communication employ instruments to paint or inscribe on flat surfaces. Khipu, by contrast, are three-dimensional arrays of knots. They consist of a primary cord, usually 0.5 to 0.7 centimeters in diameter, to which are tied thinner "pendant" strings—typically more than 100 and on occasion as many as 1500. The pendant strings, which sometimes have subsidiary strings attached, bear clusters of knots. The result, as George Gheverghese Joseph, a mathematics historian at the University of Manchester, U.K., has put it, "resembles a mop that has seen better days."

According to colonial accounts, Incan "knot-keepers"—elite bureaucrats called *khipukamayuq*—parsed the knots both by inspecting them visually and by running their fingers along them Braille-style, sometimes accompanying this by manipulating stones. For example, to assemble a history of the Inca, in 1542 colonial governor Cristóbal Vaca de Castro apparently summoned *khipukamayuq* to "read" the strings. Spanish scribes recorded their testimony but did not preserve the khipu; indeed, they may have destroyed them.

Locke showed that the numerical khipu were hierarchical, decimal arrays, with the knots used to record 1's on the lowest level of each string. Other knots were tied on successively higher levels in a decimal "place value" system to represent 10s, 100s, 1000s, and so on. "The mystery has been dispelled," exulted archaeologist Charles W. Mead after Locke's discovery. "We now know the quipu for just what it was in prehistoric times … simply an instrument for recording numbers."

But Locke's rules did not decode all of the estimated 600 khipu that survived the Spanish. Nor did they detail what objects were being accounted for in these records. According to Cornell University archaeologist Robert Ascher, about 20% of khipu are "clearly nonnumerical." In 1981, Ascher and his mathematician wife, Marcia, published a book that reignited the field by intimating that these "anomalous" khipu may have been an early form of writing.

The Aschers focused mainly on khipu knots. But in 1997, William J. Conklin, a research associate at the Textile Museum in Washington, D.C., suggested that knots were only part of the khipu system. "When I started looking at khipu," says Conklin, perhaps the first textile specialist to investigate them, "I saw this complex spinning and plying and color-coding, in which every thread was made in a complex way. I realized that 90% of the information was put into the string before the knot was made."

Taking off from this insight, Urton pro-

CREDIT: ROBERT AND MARCIA ASCHER, FROM THE COLLECTION OF MUSEO NACIONAL DE ARQUEOLOGÍA, ANTROPOLOGÍA, E HISTORIA DEL PERÚ, LIMA

poses that khipu makers made use of the nature of spinning and weaving by assigning values to a series of binary choices (see diagram), including the type of material (cotton or wool), the spin and ply direction of the string (which he describes as "S" or "Z" after the "slant" of the threads), the direction (recto or verso) of the knot attaching the pendant string to the primary, and the direction of slant of the main axis of each knot itself (S or Z). As a result, he says, each knot is a "seven-bit binary array," although the term is inexact because khipu had at least 24 possible string colors. Each array encoded one of $2^6 \times 24$ potential "information units"—a total of 1536, somewhat more than the estimated 1000 to 1500 Sumerian cuneiform signs and more than twice the approximately 600 to 800 Egyptian and Maya hieroglyphic symbols. In Urton's view, the khipu not only were a form of writing, but "like the coding systems used in present-day computer language, [they were] structured primarily as a binary code."

If Urton is right, khipu were unique. They were the world's sole intrinsically three-dimensional "written" documents (Braille is a translation of writing on paper) and the only ones to use a binary system for ordinary communication. In addition, they may have been among the few examples of "semasiographic" writing: texts that, like mathematical or dance notation but unlike written English, Chinese, and Maya, are not representations of spoken language. "A system of symbols does not have to replicate speech to communicate narrative," explains Catherine Julien, a historian of Andean cultures at Western Michigan University in Kalamazoo.

Knotted string communication, however anomalous to Euro-American eyes, has deep roots in Andean culture. Khipu were but one aspect of what Heather Lechtman, an archaeologist at the Massachusetts Institute of Technology's Center for Materials Research in Archaeology and Ethnology, describes as "a technological environment in which people solved basic engineering problems through the manipulation of fibers." In Andean cultures, Lechtman says, textiles—ranging from elaborately patterned bags and tunics to missile-hurling slings and suspension bridges—were "how people both communicated messages of all sorts and created tools." Similarly, Urton explains, binary oppositions were a hallmark of the region's peoples, who lived in societies "typified to an extraordinary degree by dual organization," from the division of town populations into "upper" and "lower" moieties to the arrangement of poetry into dyadic units. In this environment, he says, "khipu would be familiar."

But this grander view of khipu as written narrative also has its critics. "Due to cultural evolutionary theory, people have decided that cultures are not really any good unless they have writing," says Patricia J. Lyon of the Institute of Andean Studies in Berkeley, California. "People feel this great need to pump up the Inca by indicating that the khipu were writing." Agreeing with the 17th century Jesuit chronicler Bernabé Cobo, Lyon believes that khipu "were mnemonic devices, no matter what you dream up."

Even some of Urton's supporters are cautious about his interpretation. Conklin, for instance, agrees that the khipu were charged with meaning, but he worries that the analogy to computer language may not fit. "The Andean concept of duality is different than ours," he says. Whereas each 1 or 0 in a binary display is completely independent, the Andean dualities "are like the ebb and flow of a tide: opposing, interacting aspects of a single phenomenon." In his view, understanding khipu will require finding "a way other than our independent zero and one to express Andean dualism." Still, he says, Urton's work "is the first attempt to push khipu forward since Leland Locke."

Talking knots. Each knot in a khipu has its own binary signature, based on a series of choices about the kind of thread and knots used (*above*). These signatures may have encoded information and allowed Incans to "read" khipu narratives, as seen in this 16th century drawing (*right*).

CREDITS: GARY URTON, *SIGNS OF THE INKA KHIPU*, UNIVERSITY OF TEXAS PRESS (2003); FELIPE GUAMAN POMA DE AYALA

Seeking a Rosetta stone

One way to settle the debate decisively would be to find a written translation of a khipu to another language—an Incan Rosetta stone. In 1996, Clara Miccinelli, an amateur historian from the Neapolitan nobility, caused a stir by announcing that she had unearthed just such a find in her family archives: an explicit translation into Spanish of a khipu that encodes a song in Quechua, the Incan language, which is still spoken today. But because the same collection of documents also contains sensational claims about the Spanish conquest, many scholars have questioned their authenticity. Miccinelli has thus far refused to let researchers around the world freely examine the documents, although she did allow an Australian lab to use a mass spectrometer to test the khipu that accompany them. The results, published in 2000, date the khipu to between the 11th and 13th century. According to Laura Laurencich Minelli, an Andeanist at the University of Bologna working with the Miccinelli documents, the early age could be explained by the Andean tradition of weaving important khipu with old thread "charged with the strength of the ancestors."

Because they cannot examine the documents, most researchers are "strategically ignoring" them for now, says Brokaw, and are tackling khipu using less controversial means. Urton and mathematician and database manager Carrie Brezine intend to have their khipu database, which is funded by the U.S. National Science Foundation, running this fall and will eventually put it online. Their database, a successor to one set up by the Aschers at Cornell, will let scholars search for patterns across most of the 600 surviving khipu.

At the same time, Urton and other khipu hunters are searching for their own Rosetta stone: a colonial translation of a known khipu. For example, some Spanish documents from Peruvian Amazonia are thought to be transcriptions of khipu, 32 of which were recently found in the area. No definitive match has yet been made between a document and the newly discovered khipu, but Urton has uncovered some suggestive clues. He is now searching archives in Peru and Spain for more documents—a quest, according to Western Michigan's Julien, that "has a chance of bearing fruit." The 40-plus Incan provinces had similar, overlapping records, she notes. "Information from one province could easily be found in another form in another [province]." If Urton or some other scholar can find a match, she says, "we may be able to hear the Incans for the first time in their own voice." **–CHARLES C. MANN**