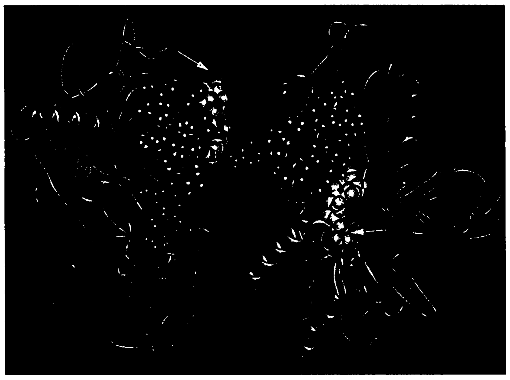


Taste block. Extra sugar molecules (red) on an altered sweet receptor may quell a mouse's sweet tooth.

buried within nontaste tissue, making direct receptor isolation difficult. And because researchers haven't been able to culture taste cells or express working receptor proteins in cultured cells of other types, they've lacked a good way to test whether candidate receptor genes respond to particular taste molecules.

The availability of the sequence of the human genome, however, has provided another way of tracking down stubborn genes. To narrow their hunt, all four teams turned to strains of mice having different sweet preferences. Some strains, called tasters, prefer liquids sweetened with sucrose or saccharin over nonsweetened solutions. Other strains, called nontasters, show no preference for sweets. Previous work by several groups had shown that genetic variations mapped to a region on the mouse genome dubbed *Sac* underlie this difference.

To home in on the specific gene involved, the researchers combed the region of the human genome sequence that corresponds to the mouse *Sac* locus. All four groups pinpointed a single gene, called *T1R3* by two of them, which seems to encode a protein with the right characteristics for a sweet receptor. The protein's sequence suggests that it is a G protein–coupled receptor—a member of a family of proteins that span the cell membrane and transmit signals into the cell via so-called G proteins. In addition, the mouse version of the gene, identified with the aid of the human gene sequence, is expressed exclusively in taste cells, and variations in the gene sequence distinguish taster mice from nontaster mice.

For example, the protein produced by nontaster mice carries a site, not found in the protein of tasters, where sugar molecules could be attached, says Margolskee. He thinks that sugars at that position could prevent receptor interactions needed to activate the internal signaling pathway. That could explain why nontaster mice are indifferent to sweets, although more work is needed to pin down whether sugars do in fact attach at that site, and if they do, whether they affect sweet taste perception.

There are also intriguing hints that *T1R3* variations might underlie differences in human responses to sweet tastes. The Monell group looked at the gene sequence of 30 human volunteers and found that 10% of them carried variations in the sequence. Although the variations are different from those distinguishing taster and nontaster mice, their positions in the sequence suggest that they are in the part of the protein that protrudes from the outside of the cell. If so, they could disrupt binding of the receptor either to a taste compound or to other receptors. Danielle Reed of Monell says their team is now looking to see if the two versions of the gene are linked to variations in sweet sensitivities of human populations.

Still, although the results strongly suggest that the researchers have finally identified a sweet receptor, they do not yet prove that beyond a shadow of a doubt. That will depend on showing that the gene from taster mice will confer sweet sensitivity, either to nontaste cells in culture or to nontaster animals.

–R. JOHN DAVENPORT

ARCHAEOLOGY

The First Urban Center In the Americas

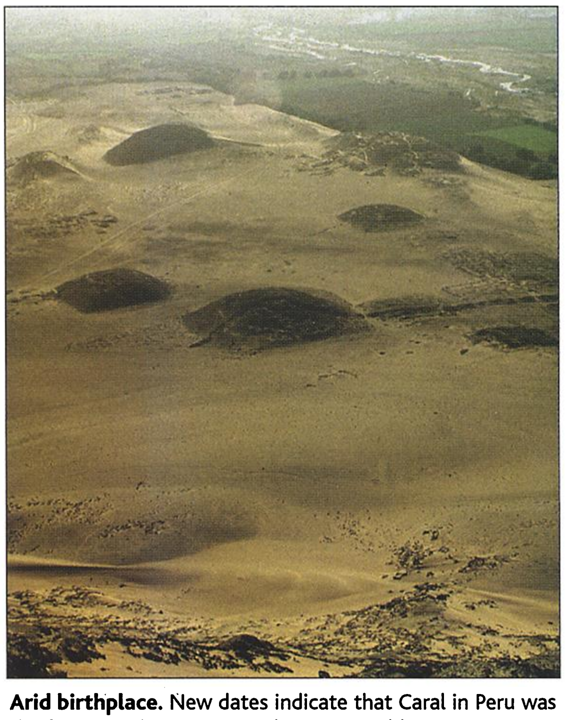
Peru's coastal desert, one of the most parched places on Earth, does not look like a particularly inviting spot for early civilization. But to the puzzlement of archaeologists, the region has given birth to a succession of spectacular cultures. Now, new dates from a Peruvian-American archaeological team working at the sprawling inland site of Caral, some 200 kilometers north of Lima, indicate that inland settlements there were even more important early on than most archaeologists had realized. The dates, published on page 723, push back the emergence of urban life and monumental architecture in the Americas by nearly 800 years—to 2627 B.C.—and cast serious doubt on one commonly held view of the relationships between inland and coastal centers in early Peru. But the research suggests an answer to the puzzle of why the desert sites became so prominent early on: Some were easy to irrigate.

"It looks like Caral is really the first complex society in the New World historically," says Jonathan Haas, a co-author of the paper and an archaeologist at the Field Museum in Chicago, who specializes in the rise of early states. "Caral gives us an opportunity to look at the development process."

Situated in the middle Supe River Valley, 23 kilometers from the Pacific Ocean, Caral was the architectural wonder of its day in the Americas. At its apogee, it boasted eight sectors of modest homes and grand stone-walled residences, two circular plazas, and six immense platform mounds built from quarried stone and river cobbles. Warrens of ceremonial rooms, which probably served as symbols of centralized religion, crowned the mounds, the largest of which towered four stories high and sprawled over an area equivalent to 4.5 football fields.

To determine the age of these structures, lead author Ruth Shady Solis, an archaeologist at the National University of San Marcos in Lima, and her associates obtained carbon-14 dates on 18 excavated plant samples from the site. Some were taken from bags woven from short-lived reeds, which the builders used for hauling stones and left inside the mounds. "The team has got very nice dates that we can associate with a specific human event," such as the building of the mounds, says Brian Billman, an archaeologist at the University of North Carolina, Chapel Hill.

Exactly what fueled the early construction boom at Caral is still unclear, but the excavators point to a new development in the Americas: irrigation agriculture. After running out of floodplain land in the Supe Valley, farmers turned to Caral, several kilometers away. To grow squash, beans, guava,



Arid birthplace. New dates indicate that Caral in Peru was the first complex society in the New World.

CREDITS: (TOP TO BOTTOM) ROBERT MARGOLSKEE; R. SHADY SOLIS *ET AL* and cotton there, they would have needed to irrigate their lands—the first people to do so in the Americas. In all likelihood, observes Haas, the geography of the Supe Valley helped greatly in this development. Today, farmers irrigate the area by cutting a shallow channel 2 kilometers upstream to a simple headgate that controls the flow; in most other Peruvian valleys, they must build far longer and deeper channels and construct a series of sophisticated gates.

As the earliest urban center in the Americas, Caral now casts doubt on a favorite idea of many Andeanists: the maritime hypothesis of the origins of Peru's civilizations. First proposed by archaeologist Michael Moseley of the University of Florida, Gainesville, in 1975, the hypothesis suggests that Peru's rich marine resources—huge schools of fish and shellfish beds—permitted early fishers and foragers to settle along the coast, build elaborate architecture, and develop complex societies, moving inland only later. But Caral is centuries older than any of the early large urban centers outside the Supe Valley. "Rather than coastal antecedents to monumental inland sites," says archaeologist Shelia Pozorski of the University of Texas–Pan American in Edinburg, "what we have now are coastal satellite villages to monumental inland sites."

One of the great challenges now is to explain how this satellite system worked. In all likelihood, the ancient Peruvians moved inland to Caral to expand their diets, adding plant carbohydrates to seafood proteins, and created their elaborate civilization in their new home. Excavations at Caral have turned up abundant fish bones and mollusk shells, and the inhabitants' ancient desiccated feces, notes Haas, "all have anchovy bones in them." But it is uncertain exactly how Caral's people, living so far from the ocean, acquired all this seafood. One possibility is that they walked half the distance, trading a commodity such as cotton for coastal fishers' surplus. "Cotton was critical for the marine exploitation," says Haas. "That's what people used to make the nets with."

Haas and Winifred Creamer, an archaeologist at Northern Illinois University in DeKalb and co-author of the paper, who is married to Haas, now hope to begin piecing together Caral's economy, examining ancient cotton production along the Peruvian coast during this period and developing a trace-element analysis for cotton fiber grown in different regions. Whether Caral really was an early center of cotton agriculture remains to be seen, but the site's new dates will certainly provoke much debate about the origins of Peru's ancient civilizations.

–**HEATHER PRINGLE**

Heather Pringle is the author of *In Search of Ancient North America*.

NEUROSCIENCE

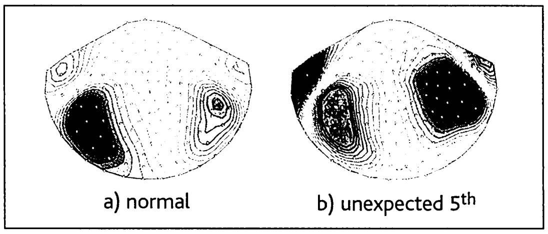
How the Brain Understands Music

The essayist Thomas Carlyle called music "the speech of angels." And indeed, music and language are being found to have quite a lot in common. A brain imaging study in the May issue of *Nature Neuroscience* confirms that people's brains are finely tuned to recognizing "musical syntax," just as they are for verbal grammar. What's more, they have found that some of this musical processing goes on in Broca's area, which is chiefly associated with language.

Physicist Burkhard Maess and colleagues at the Max Planck Institute of Cognitive Neuroscience in Leipzig, Germany, tested responses of six right-handed people with no musical training. Using magnetoencephalography (MEG), an imaging technique that uses supersensitive magnetic field detectors to register electrical activity in the brain, they measured responses to three sets of five musical chords concocted by team member Stefan Koelsch, who is also a musician. The first set were five chords in the key of C major that ended, following convention, on the tonic (C major) chord. The second and third chord sequences threw in a wild card: a "Neapolitan" chord that contains two notes that are not found in the key of C major. When inserted as the third in the five-chord sequence, this chord is a bit incongruous. When put in the fifth position it definitely sounds inappropriate, as the first four chords create the expectation of a resolution on the home (tonic) chord.

Each sequence produced a different MEG pattern, with the largest difference seen between the in-key sequence and the one ending with the Neapolitan chord. The in-key chords were mainly registered in the primary auditory cortex, located in the temporal lobes. But the incongruous set lit up areas above and in front of the temporal lobes, in the speech area known as Broca's on the left and its corresponding region on the right. The data suggest that while, just as with speech, the auditory cortex receives incoming sounds, it is Broca's area and its right-hemisphere mate that are in charge of the trickier job of making sense of them. Adds Koelsch, "We found that musical syntax is not only processed in the same area [as speech] but also with the same time-course of neural activity." (That is, brain responses to incongruities peaked at about 200 milliseconds after the stimulus, as they did in an earlier study using verbal incongruities.)

Because the effects occurred in subjects with no musical training, the study supports existing evidence that the brain has an "implicit" ability to apply harmonic principles to music, the authors write. Overall, the effects of the music were more pronounced in the right hemisphere than the left, where more speech functions are headquartered. "Currently, we cannot prove that the processes underlying language and music processing … are the same," says Maess. Nonetheless, there is "still more overlap than we thought."



Syntax of sound. Brain activity in Broca's area increases in response to an unexpected chord (b) compared with a normal one (a).

"Studies such as this teach us to be cautious when talking about 'language areas' in the brain," says Aniruddh Patel of The Neurosciences Institute in San Diego. He says the work goes against "a prevailing view that language is 'modular' [and draws] on special mental operations and brain regions that are not used by any other domain." Because linguistic and musical syntax are different, he notes, a demonstration that brain regions known to be involved in one are also involved in the other "raises the question of what these brain areas are really doing."

Even more precise probes will be required to sort that out. Neuroscientist Robert Zatorre of McGill University in Montreal says the Maess team has successfully demonstrated the "physiological trace" of musical syntax processing and shown that it overlaps with language responses. But whether they are "part of the same [system] or independent is not yet certain."

–**CONSTANCE HOLDEN**

CREDITS: (TOP TO BOTTOM) B. MAESS, S. KOELSCH, T. C. GUNTER, AND A. D. FRIEDERICI, *NATURE NEUROSCIENCE* 4, 540 (2001); ARCHIVO ICONOGRAFICO, S.A./CORBIS