SCIENCE & TECHNOLOGY

(12 to 19 miles in diameter) star made up of neutrons so densely packed that it outweighs the sun. Thought to be remnants of supernova explosions, pulsars emit directional radio beams that sweep the sky as they spin on their axes up to 30 times per second. Unlike most pulsars, however, PSR 1913+16 is a system containing two objects orbiting each other: a pulsar and a silent companion, probably another neutron star. Their orbital speeds (up to 250 miles per second) seem enough to produce powerful gravitational waves. Moreover, PSR 1913+16 is like an enormous clock: The arrival of its pulses at Earth varies precisely with its orbital position. By measuring the intervals, astronomers can discern the orbits and gauge the two bodies' gravitational effects with great accuracy.

Relativity predicts that gravitational waves thrown off as the two stars whirl in space should reduce the total amount of energy in the system. The authors reasoned that this loss would slow PSR 1913+16's orbital speed and gradually shrink both the size of its orbit and the time it takes to circle its companion. Indeed, after six years, the deviation was more than one second—almost precisely the rate predicted by relativity theory. The authors calculate that the pulsar's orbit shrinks 11.5 feet per year. Their experiment constitutes new evidence supporting relativity theory. But they may have gained practical benefits as well—by using Einstein's insights to map objects beyond the range of the strongest telescopes.

Choirs of Hominids

"Did Human Speech Originate in Coordinated Vocal Music?" by Bruce Richman, in *Semiotica* (vol. 32, nos. 3–4, 1980), Walter de Gruyter, Inc., 200 Saw Mill River Rd., Hawthorne, N.Y. 10532.

Linguists agree that present-day human speech serves many purposes, often simultaneously: to express emotion; to demand or deny; to keep the "channel of communication open"; to please the ear. Most linguists attribute to our early ancestors' speech only one function: relaying concrete information, using words as symbols. However, according to researcher Richman, humans had speech before they had words.

Richman bases his conclusion on sounds made by gelada monkeys, found in Western Africa. The geladas are the second most vocal of Old World primates (after man). They keep up a near constant chorus, inhaling and exhaling, varying long and short tones, and changing their pitch. Often two or more monkeys alternate cries in long, complex rhythmic sequences; soon other geladas pick up the pattern and chime in. According to Richman, these geladas are engaged in "contact-calling"—signaling their presence to establish, in effect, a "continuous index of . . . social solidarity." The predictability of a caller's rhythm and sound (his "syntax") is crucial, for that enables all members of the group to participate.

Intricate choral singing by present-day hunter-gatherer societies

(notably, African bushmen and Pygmies) suggests that humans created similar vocal ensembles for the same purpose even before they developed words. The complexity of their rhythmic syntaxes, made ever more complex by the need to keep everyone's interest up, says Richman, produced modern language's multifaceted structure. Without it, human speech might have followed another course: the continuous gradings of voice and meaning found among most primates.

In the wild, such grading has certain advantages. It allows primates to shift quickly among social functions: from threatening to soliciting to submitting. But the range is limited. Choral music, on the other hand, cultivated an appreciation of "discrete oppositions"—"upbeats versus downbeats, iambic versus trochee rhythms, tonic versus dominant tones," which, when words were finally developed, gave human language its sophistication.

RESOURCES & ENVIRONMENT

Wind Farms and Windmills

"A Renaissance for Wind Power" by Christopher Flavin, in *Environment* (Oct. 1981), Heldref Publications, 4000 Albemarle St. N.W., Washington, D.C. 20016.

Along with the Colt revolver, windmills played a big part in taming the arid American West. Some six million wind-powered water pumps dotted the American landscape at the end of the 19th century—before rural electrification cut short the windmill's golden age. Now, windpower may be enlisted again, in the wake of oil price increases and predictions of energy shortages. Flavin, a researcher at Worldwatch Institute, surveys the current technology.

It takes an average wind speed of 12 miles per hour to generate electricity. Although a quarter of the continental United States could theoretically support wind turbines, the Solar Energy Research Institute estimates that 3.8 million rural homes and 370,000 farms are particularly good candidates for private generators. For them, a small three- to five-kilowatt generator should suffice (cost: $5,000–$20,000). The investment is eventually recovered, but battery storage can boost the cost per kilowatt-hour to roughly three times the rate charged by utilities for oil-generated electricity. The most sophisticated small turbines permit households to use a utility's electricity on calm days and send wind-generated electricity back through the utility lines as "payment" when use is down or winds are high.

But wind is not just a "backyard" resource. Currently, Alcoa, Boeing, General Electric, Lockheed, and Westinghouse are working with the National Aeronautics and Space Administration to develop centralized