of the greater importance to hominids. The early hominids had enormous cheek teeth, and these, according to many anthropologists, were probably used to grind plant roots, seeds, and tubers.

Early hominid fossils exhibit a great deal of variability. Adults ranged in size from about 3 to 6 feet (1 foot = 0.3 meter) tall, according to Milford Wolpoff of the University of Michigan, Ann Arbor, and various hominids differed greatly in their cranial capacities and the sizes of their cheek teeth. Analyses of this variability have led to a controversy among anthropologists as to whether the fossils represent more than one lineage of hominid.

Speaking of Science

Sports: Introducing the "Happy Non Hooker"

Sports is one of the most pervasive features of modern life, but, with the possible exception of engineering improvements in automobile racing and chemical innovations on athletic fields, there has apparently been little effort to apply scientific principles to its refinement. Aluminum may have replaced wood in baseball bats and tennis rackets and the pole valuter's pole may have acquired many of the characteristics of a spring, but beyond that it is hard to find examples of technological improvement.

Now, however, two scientists from California (where else?) have combined their scientific training and a great deal of technical ingenuity to make what appears to be a significant improvement in one of the oldest modern sports—the game of golf. Fred E. Holmstrom, a physicist at San Jose State University, and Daniel A. Nepela, an advisory chemist at IBM Corporation in San Jose, are both nongolfers, but they may have solved one of the greatest plagues of amateur golfers by inventing a ball that resists hooking or slicing.

The modern golf ball, as defined by the United States Golf Association (USGA), must meet only three requirements: It must weigh no more than 1.62 ounces, must measure no less than 1.68 inches in diameter, and must not exceed a velocity of 250 feet per second when subjected to a standard impact. Within these constraints, modern golf ball manufacturers have produced what is considered to be the optimum ball by covering the rubber surface with dimples that provide aerodynamic lift and thus yield the maximum distance. If the ball is not hit squarely, however, the club face imparts an unwanted spin in which these dimples exert a sideways thrust. The principle is the same as that employed by a baseball pitcher in producing a curve ball, but the dimples accentuate the effect substantially.

The dimples produce a turbulent air flow around the ball that is markedly different from the laminar flow around the smooth surface of, for example, a Ping-Pong ball. Theoretical equations describing laminar flow can be solved relatively easily, but those for turbulent flow, Holmstrom and Nepela found, were far too difficult for them to make any realistic attempt to solve them. But they found that simpler equations could be used in conjunction with experimental results to predict the effect of small changes in the surface. What they found when they analyzed golf balls, in simplest terms, is that removing some of the dimples will decrease the tendency to hook or slice, but reduces the potential distance that the ball can travel.

To offset the distance penalty, they also incorporated a principle from Newtonian mechanics that might be termed the "spinning dumbbell rule." In simple terms, this rule predicts that two rigidly connected weights tend to spin around only one axis at a time. This angular stability is observed, for instance, when a twirled baton is tossed into the air: the baton continues to twirl in only one plane.

Combining the two concepts, then, Holmstrom and Nepela designed a ball in which dimples covering about 50 percent of the surface are confined to a band around the equator of the ball, with the poles remaining smooth. The mass of the skin, furthermore, is so distributed that there is a very slight concentration of mass in each of the poles. The ball is still spherical, however, and the changes do not effect putting.

In use, the ball is placed on the tee with the band of dimples in a vertical plane so that one pole faces the golfer. Most golf clubs are designed so that striking the ball imparts a backspin around the horizontal axis connecting the poles. With this configuration of the dimples, the spin produces lift. If the ball is not struck squarely, it would normally also spin (more slowly) around a vertical axis. But the gyroscope-like effect of the additional mass at the two poles resists this spin and keeps it to a minimum. The net effect of the changes in the surface and mass distribution is a sharp reduction in the tendency to hook and slice.

In tests by a professional golfer, the ball—dubbed the "Happy Non Hooker"—achieved more than 90 percent of the distance of a conventional ball. Holmstrom argues that the potential distance could be made comparable by minor refinement of the design. Most important, though, hooking and slicing were reduced by about 75 to 80 percent. With one golfer, for instance, the amount of slice in a 200-yard drive was reduced from 50 yards to about 10 yards.

The revolutionary ball, U.S. Pat. 3,819,190, was inspired by a trade-journal article on the aerodynamics of golf balls; it was conceived over lunch and developed in 2 years of the men's spare time. It can be manufactured for substantially the same price as conventional golf balls and theoretically should meet all requirements of the USGA, although it has not yet been submitted to them for testing. Several ball manufacturers are interested and, if further testing is successful, the ball may be manufactured in the near future. The potential financial reward for the two inventors is quite high, but their expenses are a model of frugality in science that would have pleased Benjamin Franklin. Their total expenditures —for rubber bands, plastic kitchen wrap, and household adhesive—were approximately $2.75.

—Thomas H. Maugh II