Humans do not make the world’s top 20 fastest runners. We lose our spot to animals like cheetahs and pronghorn antelope. But, do not discount yourself as a top performer; we are actually capable of outrunning cheetahs—as long as the race is longer than 600 yards.

Humans are so specialized for running that we can win in an endurance race against almost any animal, including those animals that we consider unbeatable. As one tribe of Bushmen in Africa has demonstrated, winning against the world’s fastest animals is only a matter of finding the right distance.

Throughout millions of years of evolution, terrestrial animals developed many forms of getting around, such as walking, hopping, slithering, trotting, and running. Some terrestrial animals are born to run; these “cursorial mammals” possess adaptations that make running easy and efficient. Running is a survival advantage; these animals can travel further and more quickly to find food, escape from swift predators, and catch agile prey.

Specialized Runners

Cheetahs and pronghorn antelope are two of the most specialized and successful runners—and the two fastest animals in the world. Cheetahs reach the global record at a top speed of 70 miles per hour (mph), with pronghorn antelope keeping pace at 50 mph. Cheetahs have been sprinting after antelope on the African Savannah for the last 5 million years and are well adapted to the demands of their environment (see Fig. 1). Unlike lions, which depend on the other lions in the pride to hunt, cheetahs hunt independently, using their raw speed to catch an antelope.

Their evolutionary success has been driven in part by the cheetah’s successful adaptations for the two components that drive speed: stride length and stride rate. A cheetah’s full stride, from the contact of its left front foot to the next contact of the same foot, can reach up to 25 feet in length (1). Both horses and cheetahs gather their legs underneath themselves during a gallop, with no feet touching the ground. Horses have a single airborne moment during each stride, documented by Eadweard Muybridge in 1878 with a series of photographs called “The Horse in Motion.” In comparison, cheetahs gain a second airborne suspension in a single stride when they extend both their front and hind legs (1). Like other cursorial mammals, cheetahs’ long legs help them lengthen their stride.

Long legs are good for long strides, but they limit the number of strides per second (stride rate). For example, giraffes spend their day walking, but can gallop when necessary. Giraffes’ movements are deliberate and somewhat awkward because their long, stiff legs prevent them from achieving the rapid stride rate of lions or cheetahs (see Fig. 2). The cheetah’s solution to this restriction is a flexible spine; it can coil its long legs so compactly that its front and hind feet never get tangled, which allows it to flex and extend its legs 2.5 times per second (1). In addition to a long stride and fast stride rate, a cheetah’s tail acts like a stabilizer, and its semi-retractable claws can grip the savannah ground like track cleats (2, 3).

The cheetah’s adaptations for the speed record have compromised its long-distance stamina. Its highly-specialized sprinting gallop is extremely fast, but also energetically exhausting; a cheetah can only run a distance of 1,300-2,000 ft before it tires (1). Nevertheless, those 600 yards are just long enough to chase down a swift gazelle and score a meal, leaving the lions to search for a new lunch.

Adaptations for Endurance

The second fastest land animal is a little-known New World runner: the pronghorn antelope. The pronghorn
antelope ranges from western to central North America, and is about the size and shape of an African gazelle with long, spindly legs and two pronged horns (Fig. 3). Like the cheetah, the pronghorn is a champion sprinter, but it also possesses additional adaptations for sustaining high speeds. A pronghorn antelope’s top speed is 60 mph, but it can run for several hours at 35 mph (4). At that pace, it can outrun a biking Lance Armstrong over a 3-hour section of the Tour de France (5).

The pronghorn’s efficient adaptations allow it to run for hours across the American plains, perhaps, as researchers suggested in a paper published in *Nature*, to escape from the now-extinct prehistoric American cheetah. Unlike the modern cheetah’s flexible spine, the pronghorn’s spine is less flexible but similar to the spine of a horse. A semi-flexible spine stabilizes the pronghorn’s vertical motion so that it spends less energy lifting its body into the air in each stride (1). Like horses and gazelles, pronghorn antelope have lost extraneous digits and walk on their toes, giving them more speed by reducing unnecessary bone and muscle weight at the end of their legs. Pronghorn antelope also take in and use oxygen more efficiently than most other animals. The more oxygen that pronghorn antelope breathe in, the more oxygen that reaches their muscles; hence, the faster and longer their muscles can contract to allow them to run. Their maximum oxygen uptake relative to their body size is three times the uptake of any other running or flying animal (4). Pronghorn antelope have intricate lung surfaces to absorb the most oxygen possible to make the most out of each breath. They can also skip the warm-up jog because they are perpetually “warmed up”; they keep their muscles at a higher resting temperature than other mammals of their size so they are ready to run immediately.

Who is still going after 100 miles? There is a point at which horses and dogs can no longer sustain their running pace and must stop—and then we catch up.

While the cheetah maximizes stride length and rate for intense bursts of speed and the pronghorn optimized its oxygen intake for flexible types of speed, humans specialize in long-distance marathons.

**The Human Physique**

At a first glance, we are quick to dismiss humans as wimps in the running race. Horses and dogs—not to mention cheetahs and pronghorns—can beat us effortlessly down to the end of a football field. However, what happens when one football field becomes 100 football fields or 10,000 football fields? Humans are the only primates that can run for extended periods of time; chimpanzees and gorillas are incapable of running upright for more than a few minutes. Dennis Bramble from the University of Utah and Daniel Lieberman from Harvard University believe that our ancestors’ development of running 2 million years ago may have influenced the evolution of human body. Humans evolved three ingenious adaptations that are remarkably well-suited to endurance running, allowing us to compete with the other cursorial mammals: our unique physical form, our ability to breathe, and our ability to sweat.

The human physical form is unique among animal runners. The arch of the human foot is the biological engineer’s suspension bridge and one of the most simple, yet sophisticated adaptations for running. With each step we take, the lattice of tendons and ligaments in our foot stretches to absorb shock like an earthquake-proof bridge. Our legs also absorb shock by compressing under our body, while our springy tendons and ligaments store and release energy over time. We can run for a long time because our bodies are built to conserve energy at every opportunity.

Our second unique adaptation is our ability to regulate our breathing independently of our limb movement. Because all other cursorial mammals are quadrupeds, the expansion of their ribcage—and therefore the expansion of their lungs—is limited by each stride. As a cheetah gathers its legs midstride, its momentum slams the air out of its lungs; as it extends its legs, its internal weight pulls away from its chest and allows it to expand its lungs. The cheetah cannot breathe more than once per stride.

Because humans stand upright, the movement of our legs as we walk and run does not affect the expansion of our lungs. Humans have only two gaits, walking and running. Unlike cheetahs, we can breath faster than we can move our legs, getting the maximum amount of oxygen to our muscles. The regulation of our breathing allows us to run for extended distances because we constantly remain in an energy-efficient gait.

Humans compete against other mammals with a third ingenious and unique adaptation: the ability to cool our body temperatures by sweating. Most animals cool themselves by seeking
the shade or by panting to release hot, moist air through their mouths. However, animals cannot cool themselves and run simultaneously. Harvard scientists once measured the body temperature of a cheetah on a treadmill; as soon as its temperature reached 105°F, the cheetah halted and refused to run. Sweating allows us to regulate our internal body temperatures while running, without having to stop for shade or to pant.

The combination of the foot’s arch, sweating, and breathing provides humans with unparalleled energy efficiency during an endurance run. As the distance and time of an extended run increase, we become better competitors against cursorial mammals such as horses or gazelles. Finally, at just the right distance, we can overtake them.

The Longest Race

One isolated tribe on the Kalahari plains of Africa still performs persistence hunting, pursuing a gazelle to the point of exhaustion over the course of an entire day. When a gazelle sprints away from a pursuing hunter, it breaks from a trot of 15 mph into a gallop of 30 mph until it stops 500 yards away. In the switch from a trot to a gallop, it engages in a much more exhausting form of movement than a trot. The gazelle can only gallop away for a certain distance before it is limited by its breathing rate and oxygen consumption, and slows down. However, the human hunter does not have to switch gaits to follow it and he continues to run efficiently as he speeds up from 5 mph to 12 mph. When he catches up to the gazelle, it gallops away again, and then stops. As the distance accumulates over the course of the day, the gazelle begins to tire from relentless sprinting.

After an entire day of chase, the hunter finally catches up to the gazelle. It has collapsed from heat exhaustion, and cannot get enough oxygen to its muscles to keep its legs moving. By breathing and sweating, the human has run the gazelle to its death. The human has won the evolutionary challenge, perhaps not by chasing their prey with spears, but by running them to exhaustion (6, 7).

In 1973, a man named Gordy Ainsleigh demonstrated humans’ modern endurance running ability. In June, he entered a horse race in California called the 100-mile Western States Trail Ride. At mile 29, his new horse went lame and he had to drop out of the race. When the race came around one year later, Ainsleigh decided to enter the race without his horse and compete on foot to his friends’ and family’s incredulity. He finished the race—while he did not win, he did unexpectedly finish within the 24-hour cutoff time. In 1977, so many runners decided to compete on foot that the horserace split into the equestrian Tevis Cup and the world’s first 100-mile ultramarathon, the Western States 100 (7).

While humans cannot beat dogs, horses, or cheetahs to the end of a football field, we are well adapted for races of 1,000 football fields. Although we have yet to compete directly against a pronghorn in an ultramarathon, persistence hunting shows that we are capable of running down a gazelle. Cheetahs and pronghorn antelope possess well-refined adaptations to survive and compete in their environment, whether by sprinting or sustaining high speeds, just as we possess our own unique and sophisticated specializations for endurance running (see Fig. 4).

Our evolutionary success may even be attributed to our prowess as one of the world’s most persistent endurance runners. The human body form, our ability to regulate breathing, and our ability to cool by sweating are some of the most efficient and effective designs possessed by cursorial mammals. Each adaptation is independently ingenious, but it is the human combination that creates evolutionary elegance—and lets us catch cheetahs.

References