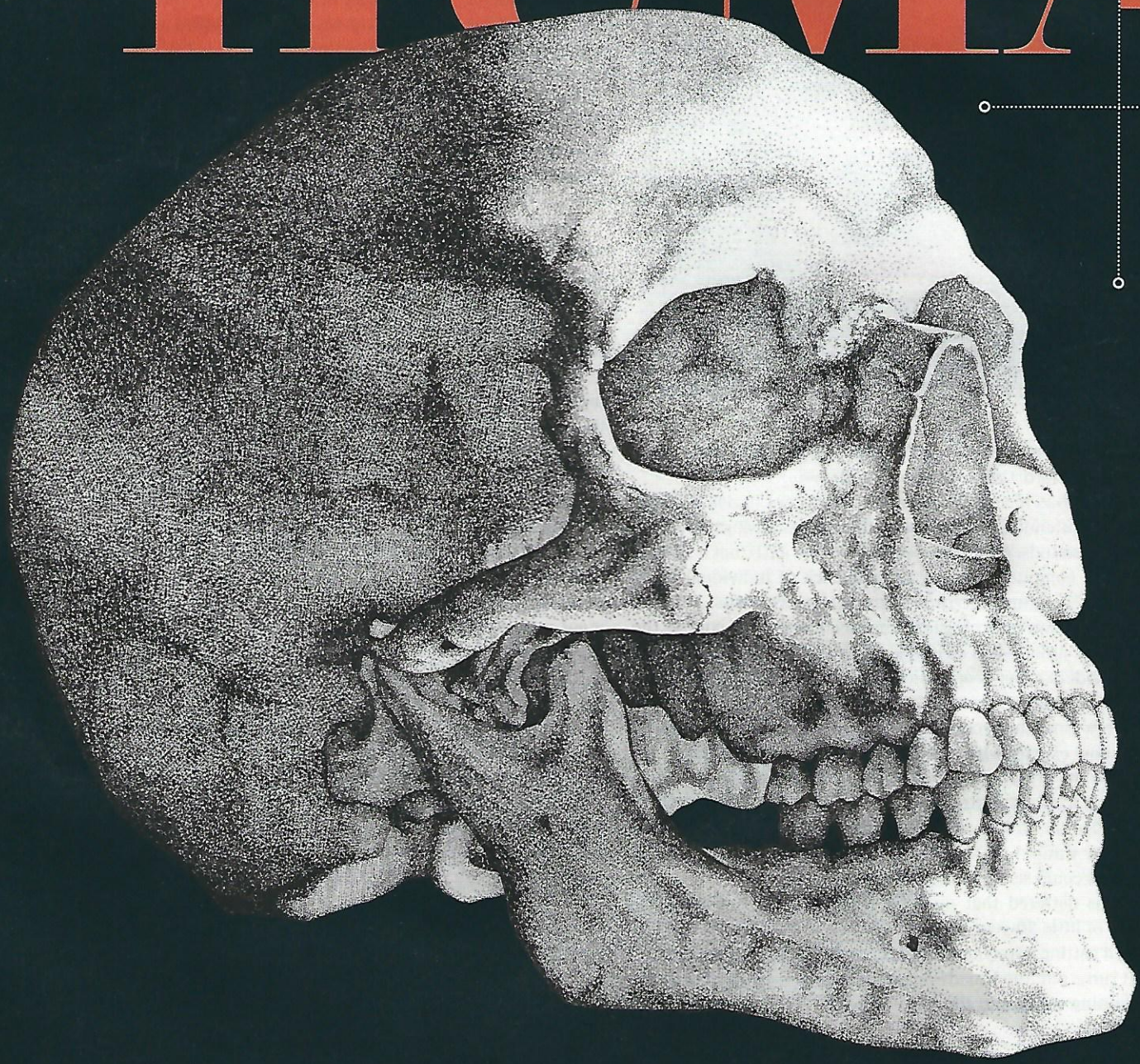
THE HUMA



N SAGA

EVOLUTION REWRITTEN

Awash in fresh insights, scientists have had to revise virtually every chapter of the human story

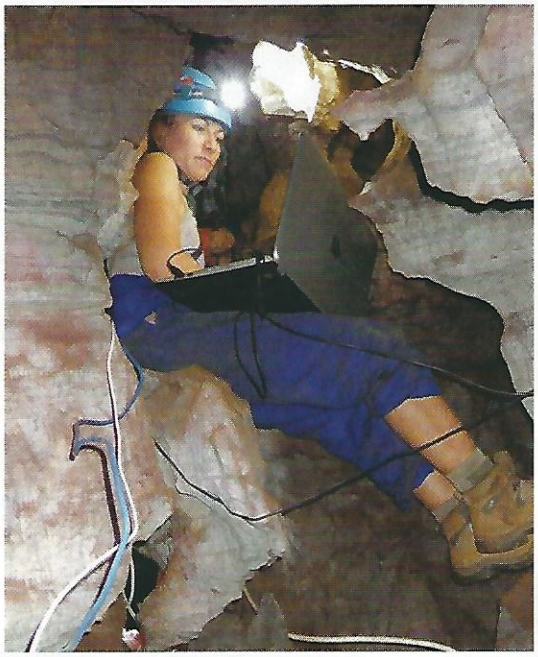
By Kate Wong

THROUGH THE POST BOX, UP THE DRAGON'S BACK, DOWN THE CHUTE AND OVER TO THE PUZZLE Box. Last fall the world followed, via tweets, blogs and videos, as scientists negotiated these fancifully named landmarks of the underground system of caves known as Rising Star just outside Johannesburg, South Africa. The tight squeezes and steep drops made for difficult, dangerous work. The researchers, however, had their eyes on the prize: fossilized remains of an extinct member of the human family. Paleoanthropological fieldwork is usually done in secret, but this time the scientists posted thrilling multimedia missives along the way for all to see.

Cavers had spotted the bones in September while surveying the lesser-known caves of the famed Cradle of Humankind region. Researchers were certain the bones were important even without knowing their age and species: most of the individuals represented in the human fossil record consist of either skull fragments or bones from the neck down. This discovery had both. The association of skull and skeletal remains alone would have earned the find a prominent spot in any human origins textbook. After excavators began unearthing the bones, they realized that they had something even bigger on their hands. It was not just one individual's remains on the cave floor, as they originally thought, it was many—an entire population of early humans.

In two short expeditions spanning a total of four weeks, a team working under the direction of paleoanthropologist Lee Berger of the University of the Witwatersrand, Johannesburg, hauled more than 1,500 bones and bone fragments from their resting spot 30 meters underground up to the expedition's science tent, where

Illustration by Katy Wiedemann



SPELUNKING SCIENTISTS, including K. Lindsay Eaves (*above left*), have recovered more than 1,500 fossils of early members of the human family (*above right*) from the Rising Star cave system outside Johannesburg, South Africa. The researchers made 3-D scans of the fossil chamber to document their work as they excavated (*right*).

researchers catalogued the fossils and filled safe after safe with the ancestral remains. Incredibly, they only scratched the surface: a myriad of bones await in the chamber. At this rate, Rising Star is shaping up to be one of the richest human fossil sites on record.

The exact significance of the find is not yet clear. Although the team went public with the recovery efforts, it has kept the scientific details under wraps. Maybe the bones represent a species new to science, one that, like the fossils Berger and his colleagues found at the nearby site of Malapa just a few years ago, casts light on the shadowy origins of our genus, *Homo*. Perhaps a pattern will emerge from the large number of individuals at the site that will reveal the structure of their social groups. Possibly, comparison of the human remains with any remains of animals at the site will illuminate how they ended up in the cave in the first place. Answers are in the offing: the discovery team is now preparing its formal description and analysis of the bones for publication.

We observers may not yet know how these fossils will rewrite the story of our origins, but history tells us that they will indeed rewrite it. The Rising Star find is only the latest in a rash of discoveries since the start of the new millennium that are upending bedrock tenets of human evolution. New fossils are adding branches to our family tree; climate data are revealing the conditions under which our predecessors evolved their hallmark traits; primate studies are homing in on exactly what distinguishes us cognitively from our great ape cousins; DNA analyses are illuminating how ancient populations interacted—and how our species continues to change. Awash in this flood of fresh insights, scientists have had to revise virtually every chapter of the human saga, from the dawn of humankind to the triumph of *Homo sapiens* over the Neandertals and other archaic species. Never has the science of human origins felt more vital; never has our story been such a compelling read.

To appreciate just how far paleoanthropology has advanced in recent years, let us revisit the late 1990s, a time when scientists seemed to have a pretty good handle on our evolution. The fossil record of humans was relatively rich (particularly compared with the then nonexistent records of our closest living relatives, the African great apes), and genetic evidence, where applicable, seemed to fit the fossil tale. Back then the conventional wisdom, in short, was that the very first hominins (the group that includes modern humans and their extinct relatives) emerged in East Africa sometime before 4.4 million years ago, followed by our genus, *Homo,* a bit more than two million years ago. Hominins did not make it off the continent until little more than a million years ago, after which they began to fil-

COURTESY OF ELEN FEUERRIEGEL (*Eaves*); COURTESY OF [illegible] (*bones with fossils and at computer screen*)

SCIENTIFIC AMERICAN ONLINE Read more about recent paleoanthropological discoveries at ScientificAmerican.com/sep2014/wong

ter into other regions of the Old World. As they settled in these new locales, new *Homo* species arose, including the Neandertals in Eurasia. These species thrived for hundreds of thousands of years until a new species from Africa began to spread across the globe. Cleverer by half and armed with cutting-edge technology and the gift of gab, *H. sapiens* took the world by storm, driving the Neandertals and other archaic forms to extinction as it rose to prominence. There was no mingling, no hybrid love children to carry Neandertal genes into the next generation, just a straight-up replacement of the old guard by the new in which *H. sapiens* at best outcompeted and at worst killed off the hominins it encountered as it expanded out of Africa. By 30,000 years ago or thereabouts, ours was the last hominin species standing. Or so the story went.

As it turns out, fossil and genetic evidence amassed since then has cast doubt on or downright disproved every element of that CliffsNotes accounting of our origins. For example, seven-million-year-old fossils from northern Chad's Djurab Desert have extended the human fossil record by more than two million years and raised the possibility that hominins emerged not in East Africa but to the west. And the nearly two-million-year-old fossils from Malapa in South Africa hint that *Homo* itself may have gotten its start in that part of the continent rather than East Africa.

Fossils from Dmanisi in the Republic of Georgia, dated to 1.78 million years ago, show that hominins began pushing out of Africa hundreds of thousands of years earlier than originally envisioned, long before *Homo* had evolved the long legs, enlarged brain and sophisticated tool kit that had previously been thought to power this expansion. And the stunning discovery of a tiny hominin species that lived on the island of Flores in Indonesia until around 17,000 years ago raises the possibility that our forebears started spreading out of Africa even earlier than the Dmanisi fossils would suggest: the exceptionally small body and brain of *Homo floresiensis,* as the Indonesian remains are known, might be traits from an australopithecinelike ancestor that blazed a trail out of Africa two million years ago or more.

Arguably, no chapter of the human odyssey has been so dramatically rewritten as the one detailing the ascent of *H. sapiens.* Far from being an evolutionary slam dunk, destined for world domination from the outset, the fossil record now paints a picture of a species that had no sooner debuted than it nearly went extinct as a result of climate change. Neither is the cognitive divide between *H. sapiens* and archaic species nearly so pronounced as some scholars had envisioned. Discoveries of sophisticated implements such as leather-burnishing tools made of animal bone reveal that Neandertals were far more technologically advanced than previously supposed. And evidence that they decorated their bodies with paint, jewelry and feathers attests to Neandertal societies steeped in symbolic traditions once believed to be unique to *H. sapiens.* The notion of Neandertals as doltish cavemen, it turns out, is a canard.

Appropriately enough given the commonalities between anatomically modern humans and the Neandertals, genetic studies have shown that the two groups interbred—frequently enough that genomes of non-African people today are up to 3 percent Neandertal. And because different people carry different bits of Neandertal DNA, the sum total of Neandertal genetic material that persists in modern-day folks is much higher than that: at least 20 percent, according to recent calculations.

The Neandertals were not the only archaic humans with whom *H. sapiens* canoodled. The recently discovered Denisovans—a group identified via DNA recovered from an enigmatic 40,000-year-old finger bone found in a Siberian cave—hooked up with our ancestors, too. Moreover, sex with archaic hominins actually seems to have benefited *H. sapiens,* allowing them to acquire genes that aided their survival: DNA inherited from Neandertals seems to have boosted immunity, for instance. And a gene variant from Denisovans helps Tibetans live at high altitudes.

And yet for all that binds us to our closest evolutionary relatives, some traits clearly set us apart. In this special issue of *Scientific American,* we explore the evolution of those characteristics that make us human—from our upright stance to our peerless ability to collaborate. Our tale has three chapters. The first examines our tangled family tree and the factors that favored the survival of our branch to the exclusion of the others. The second takes stock of how humans differ from other primates and considers how these features may have set us up to thrive. And the third ponders the future of human evolution in a world brimming with technological fixes for everything from loneliness to disease.

We hope you enjoy this story, seven million years in the making. It is not the final word, of course. Just as human evolution seems to be accelerating, so, too, is the pace of paleoanthropological discovery. But we wouldn't have it any other way. SA

Kate Wong is a senior editor at Scientific American. *She served as editor of this single-topic issue.*

WHAT'S INSIDE THIS ISSUE →