



By James Shreeve

Genetic trails left by our ancestors are leading scientists back across time in an epic discovery of human migration.

Everybody loves a good story, and when it's finished, this will be the greatest one ever told. It begins in Africa with a group of hunter-gatherers, perhaps just a few hundred strong. It ends some 200,000 years later with their six and a half billion descendants spread across the Earth, living in peace or at war, believing in a thousand different deities or none at all, their faces aglow in the light of campfires and computer screens.

In between is a sprawling saga of survival, movement, isolation, and conquest, most of it unfolding in the silence of prehistory. Who were those first modern people in Africa? What compelled a band of their descendants to leave their home continent as little as 50,000 years ago and expand into Eurasia? What routes did they take? Did they interbreed with earlier members of the human family along the way? When and how did humans first reach the Americas?

In sum: Where do we all come from? How did we get to where we are today? For decades the only clues were the sparsely scattered bones and artifacts our ancestors left behind on their journeys. In the past 20 years, however, scientists have found a record of ancient human migrations in the DNA of living people. "Every drop of human blood contains a history book written in the language of our genes," says population geneticist Spencer Wells, a National Geographic explorer-in-residence.

The human genetic code, or genome, is 99.9 percent identical throughout the world. What's left is the DNA responsible for our individual differences—in eye color or disease risk, for example—as well as some that serves no apparent function at all. Once in an evolutionary blue moon, a random, harmless mutation can occur in one of these functionless stretches, which is then passed down to all of that person's descendants. Generations later, finding that same mutation, or marker, in two people's DNA indicates that they share the same ancestor. By comparing markers in many different populations, scientists can trace their ancestral connections.

In most of the genome, these minute changes are obscured by the genetic reshuffling that takes place each time a mother and father's DNA combine to make a child. Luckily a couple of regions preserve the telltale variations. One, called mitochondrial DNA (mtDNA), is passed down intact from mother to child. Similarly, most of the Y chromosome, which determines maleness, travels intact from father to son.

The accumulated mutations in your mtDNA and (for males) your Y chromosome are only two threads in a vast tapestry of people who have

contributed to your genome. But by comparing the mtDNA and Y chromosomes of people from various populations, geneticists can get a rough idea of where and when those groups parted ways in the great migrations around the planet.

In the mid-1980s the late Allan Wilson and colleagues at the University of California, Berkeley, used mtDNA to pinpoint humanity's ancestral home. They compared mtDNA from women around the world and found that women of African descent showed twice as much diversity as their sisters. Since the telltale mutations seem to occur at a steady rate, modern humans must have lived in Africa twice as long as anywhere else. Scientists now calculate that all living humans are related to a single woman who lived roughly 150,000 years ago in Africa, a "mitochondrial Eve." She was not the only woman alive at the time, but if geneticists are right, all of humanity is linked to Eve through an unbroken chain of mothers.

Mitochondrial Eve was soon joined by "Y chromosome Adam," an analogous father of us all, also from Africa. Increasingly refined DNA studies have confirmed this opening chapter of our story over and over: All the variously shaped and shaded people of Earth trace their ancestry to African hunter-gatherers.

Looking more closely at DNA markers in Africa, scientists may have found traces of those founders. Ancestral DNA markers turn up most often among the San people of southern Africa and the Biaka Pygmies of central Africa, as well as in some East African tribes. The San and two of the East African tribes also speak languages that feature a repertoire of unique sounds, including clicks. Perhaps these far-flung people pay witness to an expansion of our earliest ancestors within Africa, like the fading ripples from a pebble dropped in a pond.

What seems virtually certain now is that at a remarkably recent date—probably between 50,000 and 70,000 years ago—one small wavelet from Africa lapped up onto the shores of western Asia. All non-Africans share markers carried by those first emigrants, who may have numbered just a thousand people.

Some archaeologists think the migration out of Africa marked a revolution in behavior that also included more sophisticated tools, wider social networks, and the first art and body ornaments. Perhaps some kind of neurological mutation had led to spoken language and made our ancestors fully modern, setting a small band of them on course to colonize the world. But other scientists see finely wrought tools and other traces of modern behavior scattered around Africa long before those first steps outside the continent. "It's not a 'revolution' if it took 200,000 years," says Alison Brooks of George Washington University.

Whatever tools and cognitive skills the emigrants packed with them, two paths lay open into Asia. One led up the Nile Valley, across the Sinai Peninsula, and north into the Levant. But another also beckoned. Seventy thousand years ago the Earth was entering the last ice age, and sea levels were sinking as water was locked up in glaciers. At its narrowest, the mouth of the Red Sea between the Horn of Africa and Arabia would have been only a few miles wide. Using primitive watercraft, modern humans could have crossed over while barely getting their feet wet.

Once in Asia, genetic evidence suggests, the population split. One group stalled temporarily in the Middle East, while the other followed the coast around the Arabian Peninsula, India, and beyond. Each generation may have pushed just a couple of miles farther.

"The movement was probably imperceptible," says Spencer Wells, who heads the National Geographic Society's Genographic Project, a global effort to refine the picture of early migrations (see page 70). "It was less of a journey and probably more like walking a little farther down the beach to get away from the crowd."

Over the millennia, a few steps a year and a few hops by boat added up. The wanderers had reached southeastern Australia by 45,000 years ago, when a man was buried at a site called Lake

Mungo. Artifact-bearing soil layers beneath the burial could be as old as 50,000 years—the earliest evidence of modern humans far from Africa.

No physical trace of these people has been found along the 8,000 miles from Africa to Australia—all may have vanished as the sea rose after the Ice Age. But a genetic trace endures. A few indigenous groups on the Andaman Islands near Myanmar, in Malaysia, and in Papua New Guinea—as well as almost all Australian Aborigines—carry signs of an ancient mitochondrial lineage, a trail of genetic bread crumbs dropped by the early migrants.

People in the rest of Asia and Europe share different but equally ancient mtDNA and Y-chromosome lineages, marking them as descendants of the other, stalled branch of the African exodus. At first, rough terrain and the Ice Age climate blocked further progress. Europe, moreover, was a stronghold of the Neandertals, descendants of a much earlier migration of pre-modern humans out of Africa.

Finally, perhaps 40,000 years ago, modern humans advanced into the Neandertals' territory. Overlapping layers of Neandertal and early modern human artifacts at a cave in France suggest that the two kinds of humans could have met.

How these two peoples—the destined parvenu and the doomed caretaker of a continent—would have interacted is a potent mystery. Did they eye each other with wonder or in fear? Did they fight, socialize, or dismiss each other as alien beings?

All we know is that as modern humans and distinctly more sophisticated toolmaking spread into Europe, the once ubiquitous Neandertals were squeezed into ever shrinking pockets of habitation that eventually petered out completely. On current evidence, the two groups interbred rarely, if at all. Neither mtDNA from Neandertal fossils nor modern human DNA bears any trace of an ancient mingling of the bloodlines.

About the same time as modern humans pushed into Europe, some of the same group that had paused in the Middle East spread east into Central Asia. Following herds of game, skirting mountain ranges and deserts, they reached southern Siberia as early as 40,000 years ago. As populations diverged and became isolated, their genetic lineages likewise branched and rebranched. But the isolation was rarely if ever complete. "People have always met other people, found them attractive, and had children," says molecular anthropologist Theodore Schurr of the University of Pennsylvania. Schurr's specialty is the peopling of the Americas—one of the last and most contentious chapters in the human story. The subject seems to attract fantastic theories (Native Americans are the descendants of the ancient Israelites or the lost civilization of Atlantis) as well as ones tinged with a political agenda. The "Caucasoid" features of a 9,500-year-old skull from Washington State called Kennewick Man, for instance, have been hailed as proof that the first Americans came from northern Europe.

In fact most scientists agree that today's Native Americans descend from ancient Asians who crossed from Siberia to Alaska in the last ice age, when low sea level would have exposed a land bridge between the continents. But there's plenty of debate about when they came and where they originated in Asia.

For decades the first Americans were thought to have arrived around 13,000 years ago as the Ice Age eased, opening a path through the ice covering Canada. But a few archaeologists claimed to have evidence for an earlier arrival, and two early sites withstood repeated criticism: the Meadowcroft Shelter in Pennsylvania, now believed to be about 16,000 years old, and Monte Verde in southern Chile, more than 14,000 years old.

The DNA of living Native Americans can help settle some of the disputes. Most carry markers that link them unequivocally to Asia. The same markers cluster in people who today inhabit the Altay region of southern Siberia, suggesting it was the starting point for a journey across the land bridge. So far, the genetic evidence doesn't show whether North and South America were populated in a single, early migration or two or three distinct waves, and it suggests only a rough range of dates, between 20,000 and 15,000 years ago. Even the youngest of those dates is older than the opening of an inland route through the Canadian ice. So how did the first Americans get here? They probably traveled along the coast: perhaps a few hundred people hopping from one pocket of land and sustenance to the next, between a frigid ocean and a looming wall of ice. "A coastal route would have been the easiest way in," says Wells. "But it still would have been a hell of a trip." Beyond the glaciers lay immense herds of bison, mammoths, and other animals on a continent innocent of other intelligent predators. Pushed by population growth or pulled by the lure of game, people spread to the tip of South America in as little as a thousand years.

The genes of today's Native Americans are helping to bring their ancestors' saga to life. But much of the story can only be imagined, says Jody Hey, a population geneticist at Rutgers University. "You can't tell it with the richness of what must have happened." With the settling of the Americas, modern humans had conquered most of the planet. When European explorers set sail 700 years ago, the lands they "discovered" were already full of people. The encounters were often wary or violent, but they were the reunions of a close-knit family.

Perhaps the most wonderful of the stories hidden in our genes is that, when unraveled, the tangled knot of our global genetic diversity today leads us all back to a recent yesterday, together in Africa.

What Genes and Fossils Tell Us

Scientists have long held that modern humans originated in Africa because that's where they've found the oldest bones. Geneticists have come to the same conclusion by looking at Africa's vast genetic diversity, which could only have arisen as DNA mutated over millennia. There's less consensus about the routes our ancestors took in their journey out of Africa and around the planet. Early migrations stalled but left behind evidence such as a human skull from 92,000 years ago at Qafzeh, Israel. Those people may have taken a northern route through the Nile Valley into the Middle East. But other emigrants who left Africa tens of thousands of years later could also have taken a different route: across the southern end of the Red Sea. Scientists say these more recent wanderers gave rise to the 5.5 billion humans living outside Africa today. "I think the broad human prehistoric framework is in place," says geneticist Peter Forster of the McDonald Institute for Archaeological Research in Cambridge, England, "and we are now fitting in the details."

1. African Cradle

Most paleoanthropologists and geneticists agree that modern humans arose some 200,000 years ago in Africa. The earliest modern human fossils were found in Omo Kibish, Ethiopia. Sites in Israel hold the earliest evidence of modern humans outside Africa, but that group went no farther, dying out about 90,000 years ago.

2. Out of Africa

Genetic data show that a small group of modern humans left Africa for good 70,000 to 50,000 years ago and eventually replaced all earlier types of humans, such as Neandertals. All non-Africans are the descendants of these travelers, who may have migrated around the top of the Red Sea or across its narrow southern opening.

3. The First Australians

Discoveries at two ancient sites—artifacts from Malakunanja and fossils from Lake Mungo—indicated that modern humans followed a coastal route along southern Asia and reached Australia nearly 50,000 years ago. Their descendants, Australian Aborigines, remained genetically isolated on that island continent until recently.

4. Early Europeans

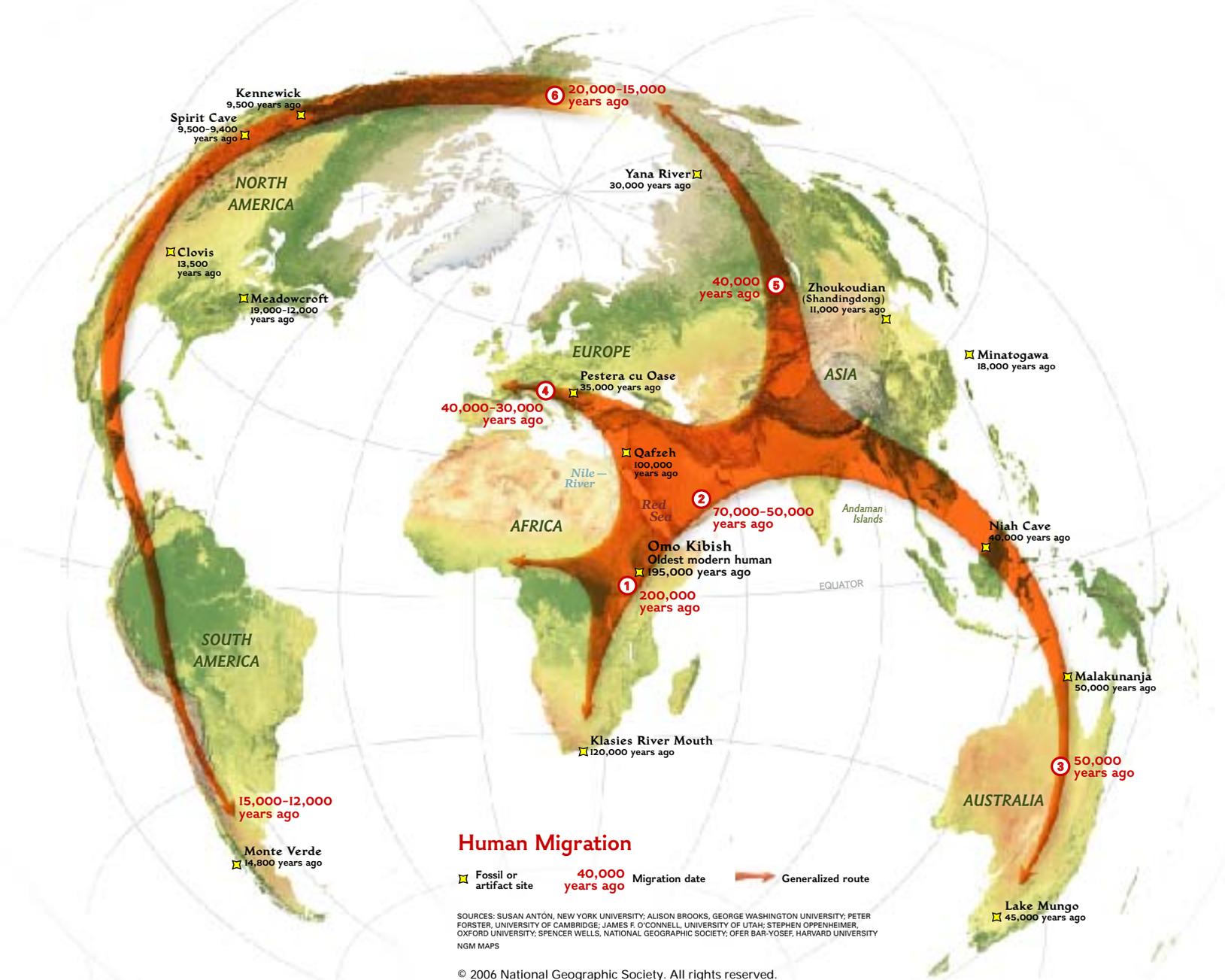
Paleoanthropologists long thought that the peopling of Europe followed a route from North Africa through the Levant. But genetic data show that the DNA of today's western Eurasians resembles that of people in India. It's possible that an inland migration from Asia seeded Europe between 40,000 and 30,000 years ago.

5. Populating Asia

Around 40,000 years ago, humans pushed into Central Asia and arrived on the grassy steppes north of the Himalaya. At the same time, they traveled through Southeast Asia and China, eventually reaching Japan and Siberia. Genetic clues indicate that humans in northern Asia eventually migrated to the Americas.

6. Into the New World

Exactly when the first people arrived in the Americas is still hotly debated. Genetic evidence suggests it was between 20,000 and 15,000 years ago, when sea levels were low and land connected Siberia to Alaska. Ice sheets would have covered the interior of North America, forcing the new arrivals to travel down the west coast.



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