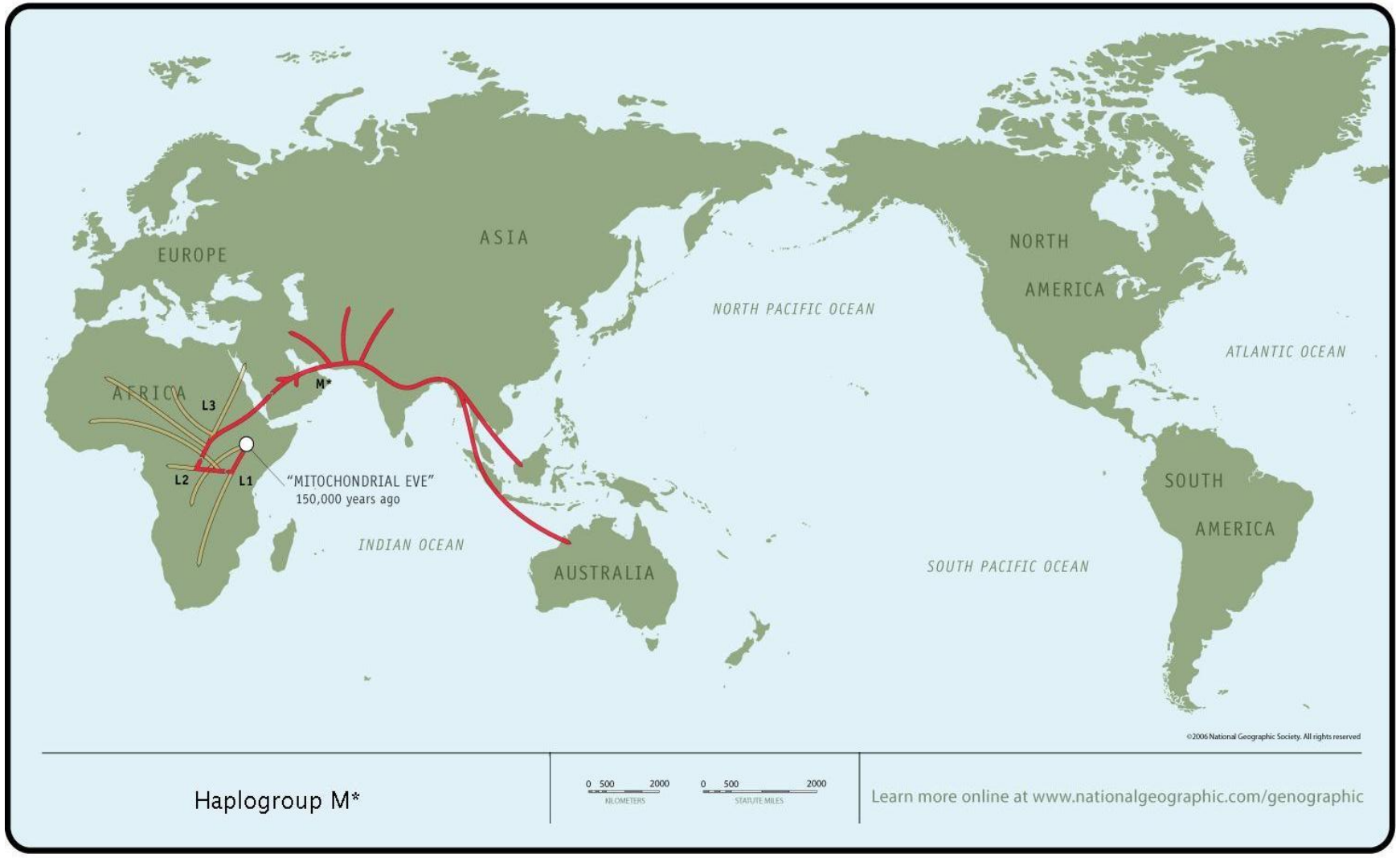
THE GENOGRAPHIC PROJECT

MIGRATION ROUTES: SUNG-PENG HSU



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THE GENOGRAPHIC PROJECT

Certificate of mtDNA testing

In recognition of your participation in the Genographic Project, we hereby certify that

SUNG-PENG HSU

belongs to:

Haplogroup M*

The letters designating the bases adenine, cytosine, guanine, or thymine of your mtDNA differ from Cambridge Reference Sequence (CRS) at each of the folloiwng positions:

16129A, 16192T, 16223T, 16297C

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June 15, 2012

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Haplogroup M*

Your Branch on the Human Family Tree

Your DNA results identify you as belonging to a specific branch of the human family tree called **haplogroup *M****.

The map above shows the direction that your maternal ancestors followed as they set out from their original homeland in East Africa. While humans did travel many different paths during a journey that took tens of thousands of years, the lines above represent the dominant trends in this migration.

Over time the descendants of your ancestors were the first modern humans to leave Africa and headed east, moving across the Arabian Peninsula, through the Indian subcontinent and on to eastern Asia and Australasia. But before we can take you back in time and tell their stories, we must first understand how modern science makes this analysis possible.

How DNA Can Help

*(To follow along, click **See Your DNA Analysis** above to view the data produced from your cheek scraping.)*

The string of 569 letters shown above is your mitochondrial sequence, with the letters *A, C, T,* and *G* representing the four nucleotidesthe chemical building blocks of lifethat make up your DNA. The numbers at the top of the page refer to the positions in your sequence where informative mutations have occurred in your ancestors, and tell us a great deal about the history of your genetic lineage.

Here's how it works. Every once in a while a mutationa random, natural (and usually harmless) changeoccurs in the sequence of your mitochondrial DNA. Think of it as a spelling mistake: one of the "letters" in your sequence may change from a *C* to a *T,* or from an *A* to a *G.*

*(Explore the **Genetics Overview** to learn more about population genetics.)*

After one of these mutations occurs in a particular woman, she then passes it on to her daughters, and her daughters' daughters, and so on. (Mothers also pass on their mitochondrial DNA to their sons, but the sons in turn do not pass it on.)

Geneticists use these markers from people all over the world to construct one giant mitochondrial family tree. As you can imagine, the tree is very complex, but scientists can now determine both the age and geographic spread of each branch to reconstruct the prehistoric movements of our ancestors.

By looking at the mutations that *you* carry, we can trace your lineage, ancestor by ancestor, to reveal the path they traveled as they moved out of Africa. Our story begins with your earliest ancestor. Who was she, where did she live, and what is her story?

*(Click **Explore Your Route Map** on the right side of the page to return to the map showing your*

haplogroup's ancestral journey.)

Your Ancestral Journey: What We Know Now

We will now take you back through the stories of your distant ancestors and show how the movements of their descendants gave rise to your mitochondrial lineage.

Each segment on the map above represents the migratory path of successive groups that eventually coalesced to form your branch of the tree. We start with your oldest ancestor, "Eve," and walk forward to more recent times, showing at each step the line of your ancestors who lived up to that point.

Mitochondrial Eve: The Mother of Us All

Ancestral Line: "Mitochondrial Eve"

Our story begins in Africa sometime between 150,000 and 170,000 years ago, with a woman whom anthropologists have nicknamed "Mitochondrial Eve."

She was awarded this mythic epithet in 1987 when population geneticists discovered that all people alive on the planet today can trace their maternal lineage back to her.

But Mitochondrial Eve was not the first female human. *Homo sapiens* evolved in Africa around 200,000 years ago, and the first hominidscharacterized by their unique bipedal statureappeared nearly two million years before that. Though *Homo sapiens* have been around for about 200,000 years, about 150,000 to 170,000 years ago, a woman was born from whom we are all descended. This happened 30,000 years after *Homo sapiens* evolved in Africa.

Eventually, for any number of reasons, all of the other lineages of people went extinct, and "Mitochondrial Eve" as we call her, was the only female who had descendants that are now living in the present day. We can all be traced back to that one woman, who lived about 170,000 years ago.

Which begs the question, "So why Eve?"

Simply put, Eve was a survivor. A maternal line can become extinct for a number of reasons. A woman may not have children, or she may bear only sons (who do not pass her mtDNA to the next generation). She may fall victim to a catastrophic event such as a volcanic eruption, flood, or famine, all of which have plagued humans since the dawn of our species.

None of these extinction events happened to Eve's line. It may have been simple luck, or it may have been something much more. It was around this same time that modern humans' intellectual capacity underwent what author Jared Diamond coined the Great Leap Forward. Many anthropologists believe that the emergence of language gave us a huge advantage over other early human species. Improved tools and weapons, the ability to plan ahead and cooperate with one another, and an increased capacity to exploit resources in ways we hadn't been able to earlier, all allowed modern humans to rapidly migrate to new territories, exploit new resources, and outcompete and replace other hominids, such as the Neandertals.

It is difficult to pinpoint the chain of events that led to Eve's unique success, but we can say with

certainty that all of us trace our maternal lineage back to this one woman.

The *L* Haplogroups: The Deepest Branches

Ancestral line: "Eve" > *L1/L0*

Mitochondrial Eve represents the root of the human family tree. Her descendents, moving around within Africa, eventually split into two distinct groups, characterized by a different set of mutations their members carry.

These groups are referred to as *L0* and *L1,* and these individuals have the most divergent genetic sequences of anybody alive today, meaning they represent the deepest branches of the mitochondrial tree. Importantly, current genetic data indicates that indigenous people belonging to these groups are found exclusively in Africa. This means that, because all humans have a common female ancestor, "Eve," and because the genetic data shows that Africans are the oldest groups on the planet, we know our species originated there.

Haplogroups *L1* and *L0* likely originated in East Africa and then spread throughout the rest of the continent. Today, these lineages are found at highest frequencies in Africa's indigenous populations, the hunter-gatherer groups who have maintained their ancestors' culture, language, and customs for thousands of years.

At some point, after these two groups had coexisted in Africa for a few thousand years, something important happened. The mitochondrial sequence of a woman in one of these groups, *L1,* mutated. A letter in her DNA changed, and because many of her descendants have survived to the present, this change has become a window into the past. The descendants of this woman, characterized by this signpost mutation, went on to form their own group, called *L2.* Because the ancestor of *L2* was herself a member of *L1,* we can say something about the emergence of these important groups: Eve begat *L1,* and *L1* begat *L2.* Now we're starting to move down your ancestral line.

Haplogroup L2: West Africa

Ancestral line: "Eve" > *L1/L0* > *L2*

L2 individuals are found in sub-Saharan Africa, and like their *L1* predecessors, they also live in Central Africa and as far south as South Africa. But whereas *L1/L0* individuals remained predominantly in eastern and southern Africa, your ancestors broke off into a different direction, which you can follow on the map above.

L2 individuals are most predominant in West Africa, where they constitute the majority of female lineages. And because *L2* individuals are found at high frequencies and widely distributed along western Africa, they represent one of the predominant lineages in African-Americans. Unfortunately, it is difficult to pinpoint where a specific *L2* lineage might have arisen. For an African-American who is *L2*the likely result of West Africans being brought to America during the slave tradeit is difficult to say with certainty exactly where in Africa that lineage arose.

Fortunately, collaborative sampling with indigenous groups is currently underway to help learn more about these types of questions and to possibly bridge the gap that was created during those transatlantic voyages hundreds of years ago.

Haplogroup L3: Out of Africa

Ancestral line: "Eve" > *L1/L0* > *L2* > *L3*

Your next signpost ancestor is the woman whose birth around 80,000 years ago began haplogroup *L3.* It is a similar story: an individual in *L2* underwent a mutation to her mitochondrial DNA, which was passed onto her children. The children were successful, and their descendants ultimately broke away from the *L2* clan, eventually separating into a new group called *L3.* You can see above that this has revealed another step in your ancestral line.

While *L3* individuals are found all over Africa, including the southern reaches of sub-Sahara, *L3* is important for its movements north. You can follow this movement of the map above, seeing first the expansions of *L1/L0,* then *L2,* and followed by the northward migration of *L3.*

Your *L3* ancestors were significant because they are the first modern humans to have left Africa, representing the deepest branches of the tree found outside of that continent.

Why would humans have first ventured out of the familiar African hunting grounds and into unexplored lands? It is likely that a fluctuation in climate may have provided the impetus for your ancestors' exodus out of Africa.

The African Ice Age was characterized by drought rather than by cold. Around 50,000 years ago the ice sheets of northern Europe began to melt, introducing a period of warmer temperatures and moister climate in Africa. Parts of the inhospitable Sahara briefly became habitable. As the drought-ridden desert changed to savanna, the animals your ancestors hunted expanded their range and began moving through the newly emerging green corridor of grasslands. Your nomadic ancestors followed the good weather and plentiful game northward across this Saharan Gateway, although the exact route they followed remains to be determined.

Today, *L3* individuals are found at high frequencies in populations across North Africa. From there, members of this group went in a few different directions. Some lineages within *L3* testify to a distinct expansion event in the mid-Holocene that headed south, and are predominant in many Bantu groups found all over Africa. One group of individuals headed west and is primarily restricted to Atlantic western Africa, including the islands of Cabo Verde.

Other *L3* individuals, your ancestors, kept moving northward, eventually leaving the African continent completely. These people currently make up around 10 percent of the Middle Eastern population, and gave rise to two important haplogroups that went on to populate the rest of the world.

Haplogroup *M:* The Coastal Migrants

Ancestral line: "Eve" > *L1/L0* > *L2* > *L3* > ***M***

Your next signpost ancestor is the woman whose descendants formed haplogroup *M.* Haplogroup *M* comprises one of two groups that were created from *L3.*

One of these two groups, haplogroup *N,* moved north out of Africa and left the continent across the Sinai Peninsula, in present-day Egypt. Faced with the harsh desert conditions of the Sahara, their ancestors likely followed the Nile basin, which would have proved a reliable water and food supply in

spite of the surrounding desert and its frequent sandstorms. The ancient members of haplogroup *N* spawned many sub-lineages that went on to populate much of the rest of the globe. They are found throughout Asia, Europe, India, and the Americas.

Your haplogroup, *M*,* constitutes the other group that split off from *L3,* and gave rise to the first wave of modern humans to make a successful exodus from Africa. These people likely left the continent across the Horn of Africa, where a narrow span of water between the Red Sea and the Gulf of Aden separates the East African coastline from the Arabian Peninsula at Bab-el-Mandeb. The short ten miles would have been easily navigable for humans possessing early maritime technologies. This crossing constituted the start of a long coastal migration eastward across the Middle East and southern Eurasia, eventually reaching all the way to Australia and Polynesia.

Haplogroup *M** is considered an east Eurasian lineage, as it is found at high frequencies east of the Arabian Peninsula. Members of this group are virtually absent in the Levant (a coastal region in what is now Lebanon), though they are present at higher frequencies in the south-Arabian Peninsula at around 15 percent. Because its age is estimated at around 60,000 years old, members of this group were likely the first humans to leave Africa, and they likely did it heading east. Haplogroup *M* is found in East Africa, though at much lower frequencies than its subgroup *M1.* It gives the appearance of a more recent age in eastern Africa than in Asia which is likely the result of smaller populations in Africa, which would have reduced genetic diversity and would therefore appear more recent.

Your haplogroup is prevalent among populations living in the southern parts of Pakistan and northwest India, where it constitutes around 30 to 50 percent of the mitochondrial gene pool, depending on the population. Conversely, the *M** haplogroup is absent or rarely found amongst people living west of the Indus Valley, and is found at low frequencies in the Central Asian populations, around 10 to 15 percent. The wide distribution and greater genetic diversity east of Indus Valley indicates that these haplogroup *M**-bearing individuals are the legacy of the first inhabitants of southwestern Asia. These people underwent important expansions during the Paleolithic, and the fact that some East Asian haplogroup *M** lineages match those found in Central Asia indicates much more recent (i.e., not founder) mixture into the area from the east.

Haplogroup *M** has several sub-branches which exhibit some geographic specificity. Subgroup *M1* is found at high frequency in East Africa, at around 20 percent in many populations. Because haplogroup *M** itself is almost entirely absent from the region, M1 individuals likely represent migrations back into the continent from the Arabian Peninsula after people had left Africa. *M2-M6* are characteristic Indian sub-groups. Haplogroup *M7* is distributed across the southern part of East Asia, and two of its own daughter-groups, *M7a* and *M7b2,* are representative of Japanese and Korean populations, respectively. *M7* individuals reach frequency in southern China and Japan of around 15 percent, and are found at lower frequencies in Mongolia. The old age of this branch indicates a pre-Jomon contribution to the mitochondrial gene pool in those areas.

Anthropology vs. Genealogy

DNA markers require a long time to become informative. While mutations occur in every generation, it requires at least hundredsnormally thousandsof years for these markers to become windows back into the past, signposts on the human tree.

Still, our own genetic sequences often reveal that we fall within a particular sub-branch, a smaller, more recent branch on the tree.

While it may be difficult to say anything about the history of these sub-groups, they do reveal other people who are more closely related to us. It is a useful way to help bridge the anthropology of population genetics with the genealogy to which we are all accustomed.

One of the ways you can bridge this gap is to compare your own genetic lineage to those of people living all over the world. Mitosearch.org is a database that allows you to compare both your genetic sequence as well as your surname to those of thousands of people who have already joined the database. This type of search is a valuable way of inferring population events that have occurred in more recent times (i.e., the past few hundred years).

Looking Forward (Into the Past): Where Do We Go From Here?

Although the arrow of your haplogroup currently ends across Southeast Asia and Australia, this is not the end of the journey for haplogroup *M*.* This is where the genetic clues get murky and your DNA trail goes cold. Your initial results shown here are based upon the best information available todaybut this is just the beginning.

A fundamental goal of the Genographic Project is to extend these arrows further toward the present day. To do this, Genographic has brought together ten renowned scientists and their teams from all over the world to study questions vital to our understanding of human history. By working together with indigenous peoples around the globe, we are learning more about these ancient migrations.

Help Us Find More Clues!

But there is another way that we will learn more about the past. By contributing your own results to the project, you will be allowed to participate anonymously in this ongoing research effort. This is important because it may contribute a great deal to our understanding of more recent human migrations. Click the yellow button below in the "Help Us Tell the Story" section of your results profile to learn more about this. It's quick, easy, and anonymous, but will help us further refine our analyses.

Don't Be a Stranger

Finally, keep checking these pages to follow along with the project and our latest findings; your results profile will be automatically updated to reflect any new information that may come to light based on the research.