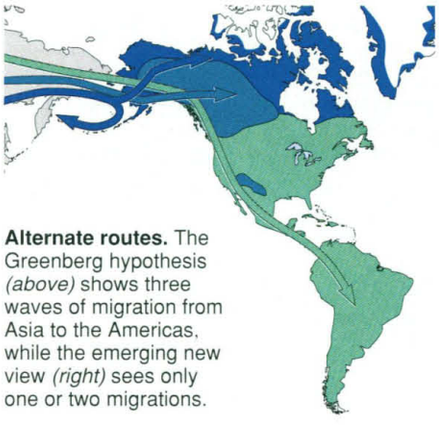
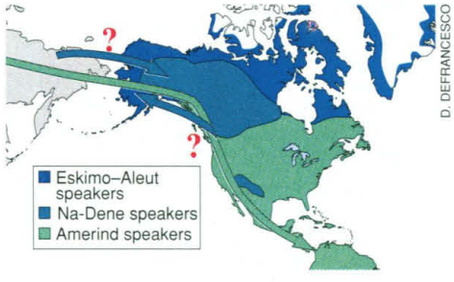
The Peopling of the Americas

New genetic data suggest that the earliest Americans came from Asia in one or two waves—not more—challenging an earlier synthesis of linguistic, dental, and genetic evidence

Six years ago, D. Andrew Merriwether was a master's student in the lab of geneticist Douglas Wallace at Emory University in Atlanta, learning to use genes to trace the ancestry of native American peoples. When he left to pursue doctoral studies at the University of Pittsburgh, Merriwether continued that research, expecting to bolster the conclusion coming from the Wallace lab: that genetically distinct groups of prehistoric people migrated to the Americas in three separate waves. But this year, Merriwether found himself publicly contradicting his mentor, in a series of papers suggesting that there was only a single migration. Although





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Alternate routes. The Greenberg hypothesis *(above)* shows three waves of migration from Asia to the Americas, while the emerging new view *(right)* sees only one or two migrations.

they remain personally friendly, mentor and student clearly are divided on this issue. Says Merriwether, now at the University of Michigan: "I feel badly about it because Wallace is the one who inspired me to go into this field. It's awkward."

Chalk up one more disagreement to one of the most contentious issues in human prehistory: the question of who settled the Americas. A decade ago, intellectual battles raged over a bold synthesis of linguistic, genetic, and dental data named after co-creator Joseph Greenberg, a Stanford University linguist. The Greenberg theory suggested that the first Americans arrived from Asia in at least three separate waves, each wave giving rise to one of three linguistic groups. Linguists opposed putting the diverse languages of most native Americans into one "Amerind" group, but the theory fit dental and genetic evidence from several labs, including Wallace's.

But now the pillar of support from genetics is showing cracks, thanks to new data from Merriwether and others, including a European team whose review is published in the October issue of the *American Journal of Human Genetics*. Additional DNA samples and better resolution show that native Americans as diverse as the Eskimos of Alaska and the Kraho and Yanomami of Brazil share more gene types than previously thought, which suggests that they are descended from the same founding populations in Asia—and that their ancestors entered North America in only one or two migratory waves, says Oxford University evolutionary geneticist Ryk Ward. Scientists are already searching for those ancestors' closest kin in Siberia and Mongolia.

Not surprisingly, not everyone supports the new interpretations. Greenberg, for example, says that given the flip-flopping conclusions from the DNA data, he's simply ignoring it until geneticists reach consensus. Others caution against putting too much weight on any one type of genetic data, and Wallace still concludes that native Americans arrived in three migrations. He's philosophical about the new work, saying that "testing new hypotheses is what research is all about." But if the new studies are right, the notion of three or more separate migrations is unlikely, and the whole idea of marrying linguistic and genetic data comes into question (see box). "This tends to confirm our conclusion that there isn't a relationship between genetic signatures of migrations and language," says Ward.

Evolutionary triangle

The Greenberg hypothesis, although controversial, had great appeal because it synthesized so many independent lines of evidence. And no matter what one was comparing—languages, teeth, or genes—the magic number was three. There were three linguistic groupings: Amerind (spoken by American Indians), Eskimo-Aleut (spoken by Eskimos and Aleutian Islanders), and Na-Dene (spoken by people of the Northwest coast of Canada and the United States). There were also three types of molar shapes and three genetically distinct populations. "Every time you come around, it's three," says Arizona State University bioarchaeologist Christy Turner, co-author of the hypothesis.

The dates also meshed with existing archaeological data. Using the degree of difference among languages, Greenberg calculated that the first language arrived in Alaska about 12,000 years before the present. That fits in with the first widely accepted archaeological evidence of culture in the Americas, the 11,500-year-old sites of the Clovis people.

At first, the genetic evidence seemed to tie in, too. Indeed, in the early 1990s, some of the best supporting evidence for the Greenberg hypothesis came from genes (*Science*, 15 January 1993, p. 312). In general, the more similar genes are among two populations, the more closely the populations are related. To trace these similarities in native American DNA, Wallace, working with geneticist Antonio Torroni, now at the University of Rome, and graduate student Theodore Schurr, assembled hundreds of blood samples from 24 tribes from Alaska to Argentina. They analyzed the DNA coiled in the mitochondria, the energy factories of the cell. Most anthropological studies use this mtDNA because it mutates faster than nuclear DNA, allowing researchers to distinguish populations that recently separated. The mtDNA is also inherited only from mothers and so avoids the gene shuffling that can obscure the evolutionary trail of most nuclear genes.

Wallace's group used particular enzymes to cut the DNA into standard pieces, then looked for variations in the length of those segments—called restriction fragment length polymorphisms (RFLPs)—to indicate the presence of mutations. They got intriguing results, finding that native Americans carry only four variants of mtDNA, called haplogroups A, B, C, and D, with each group characterized by a different set of mutations. These variants were found in some East Asians and Siberians (but not in Europeans or Africans), which indicated that the mutations originally came from Asia. Not every indigenous group seemed to carry all four, however. Wallace's team found, for example, that although most Amerind speakers carried all four haplo-

groups, Na-Dene speakers carried just one (haplogroup A), and the Eskimo-Aleut speakers carried two (haplogroups A and D). So the team concluded that Amerind speakers descended from women who carried all four types, while the other two groups descended from women who carried just one or two. And this suggested that they came to the New World in three distinct waves from Asia, just as Greenberg had proposed.

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Diverse descendants. Greenberg proposed that the ancestors of these peoples came to the Americas in three separate waves: Eskimos (Eskimo-Aleut speakers, *left*); the Maya (Amerind speakers, *bottom left*); and the Tlingit (Na-Dene speakers, *bottom right*).

New-Wave models

But just as it seemed a consensus was emerging, geneticists cast their net wider, testing the DNA of more native Americans and Asians and, in some cases, looking directly at DNA sequences. Merriwether, for example, was analyzing DNA samples of 1300 American Indians and other native groups, and he kept finding people, such as the Yanomami of Brazil, whose genes didn't fit in the four lineages identified by Wallace's team. Not only were there more than four genetic variants, but the four original types showed up in all three major language groups. Merriwether's work was confirmed by a group of South American researchers, led by Nestor A. Bianchi of the Multidisciplinary Institute of Cellular Biology in Argentina, who analyzed mtDNA from 25 populations and observed the same results.

The presence of all four markers in each of the three linguistic groups makes it unlikely that the groups' ancestors came in different migrations thousands of years apart, says Merriwether. "Think of the source population as a bowl of colored marbles," says Smithsonian Institution molecular anthropologist Connie Kolman. "You won't pick out the [same combination of] rare types three of four times if you reach in randomly." So Merriwether and University of Pittsburgh geneticist Robert Ferrell joined forces with Francisco Rothhammer of the University of Chile to propose just a single migration, in which the first women to set foot in America carried all four haplogroups.

Once in America, this first wave of settlers spread out. Some pushed south, but others stayed in the northwest, where their numbers were drastically reduced—perhaps by bitter cold during the last glacial period that ended about 11,500 years ago. As a result, the northern populations, the ancestors of the Na-Dene and Eskimo-Aleuts, lost their original genetic diversity. Their numbers eventually bounced back, but with fewer copies of haplogroups B, C, and D than carried by their southern relatives.

The latest word on the settling of the Americas comes from Europe—and it too challenges the three-migration theory. An interdisciplinary group tackled the problem by re-analyzing recent data on mtDNA sequences, pooling studies of DNA from a total of 574 native Americans and Siberians, says molecular biologist Peter Forster, a graduate student working with Hans-Jurgen Bandelt of Hamburg University, Rosalind Harding of the Institute of Molecular Medicine at Oxford, and Torroni in Rome.

Instead of looking for markers that may accompany mutations, this team looked directly at the DNA sequences—a slower but more certain way to find variations. They entered mtDNA sequences into a computer and searched for matches between American tribes, Asians, and Siberians. Ironically, they found all four of the original variants in almost all the Amerinds—supporting the part of the Greenberg hypothesis

Can This Marriage Be Saved?

In 1986, a linguist, an archaeologist, and a geneticist got together and proposed a match between languages and genes in native American groups. The brainchild of their interdisciplinary union was the Greenberg hypothesis, named for Stanford University linguist Joseph Greenberg. They proposed that three separate migrations from Asia gave rise to three groups distinct in both genes and language: the American Indians of North and South America, who speak Amerind languages; the Eskimos and Aleuts, who speak Eskimo-Aleut; and a third group including other Northwestern tribes such as the Haida and Tlingit, who speak languages in the Na-Dene family.

But as one member of the union runs into trouble—the genetic evidence (see main text)—many linguists say that it was a shotgun marriage from the start. Historical linguists say they never agreed that native American languages fall into the three broad groups Greenberg identified. Over the years, they have poked holes in Greenberg's data showing similarities among the different Amerind languages, says linguist Sarah G. Thomason of the University of Pittsburgh. Linguists also say it's impossible to trace the family tree of Amerind languages back to one 12,000-year-old ancestor, because written records go back only 5000 years.

Even if the language patterns are real, they may not imply anything about the genetic relationships of the people who speak them. "Most linguists don't think that there's a correlation between genes and language," says Thomason. Counters Smithsonian Institution anthropologist Connie Kolman: "I don't think languages can tell us anything about the initial colonization of the Americas."

Indeed, geneticists are divided on whether people in well-established language groups show matching genetic patterns in the Americas. Stanford University geneticist L. Luca Cavalli-Sforza, for example, is convinced that such correlations exist, based on a wide range of DNA, chromosomal, and blood-group data. But others aren't so sure. Oxford University evolutionary geneticist Ryk Ward is testing the notion by studying the DNA of Na-Dene speakers and Eskimo-Aleuts—linguistic groups thought to be quite distinct. But his data indicate that genetically, these groups are "remarkably similar to each other." If that finding holds up, says Ward, Greenberg's interdisciplinary union will be in trouble. **–A.G.**

that linguists dislike most, namely that the ancestors of all the Amerinds came in one wave. Overall, their more powerful method detected nine founding mtDNA sequences in native American peoples, and some of these sequences were only in Na-Dene speakers, Eskimos, and coastal Siberians, suggesting that those groups emerged from a common ancestral population, not from separate groups, as Wallace had proposed.

The team put this data together and proposed that the ancestors of the Amerinds came in the first wave from northeastern Siberia and carried all the variants, some of which were lost in northern Asians and Americans, perhaps due to climate. Later, the survivors rebounded, probably in Beringia, and gave rise to the Na-Dene and Eskimos. This scenario allows for either one or two migrations into North America, depending on whether the homeland of the surviving northerners was in North America or Siberia. Forster says: "We call it a re-expansion. It's a matter of taste whether you call it a separate migration."

The European group also explored an even more controversial issue, the timing of these migrations, by using the amount of genetic difference among populations as a molecular clock. The Amerind speakers show the most diversity, so the team concluded that they arrived in the first wave, 20,000 to 25,000 years ago. That predates the Clovis culture but matches dates from Wallace's group and from several new South American archaeological sites (*Science*, 19 April, p. 346). The re-expansion, they say, happened about 11,300 years ago—the time of the Clovis people.

In search of a homeland

If all of today's native Americans do go back to a single population in Asia, which one? The multiple-migration advocates put their founders in Siberia, as does the European team, because Siberians share some founding variants with Na-Dene speakers and Eskimos—and live close to the land bridge to the Americas. Merriwether and Kolman are skeptical, however, because all modern Siberians tested so far lack haplogroup B. In separate papers, Merriwether, and Kolman and her Smithsonian colleague Eldredge Bermingham have proposed that the founders may have been Mongolians, because they carry all four haplogroups.

Even on the number of migrations, there is no consensus. Satoshi Horai of the National Institute of Genetics in Mishima, Japan, for example, notes that his analyses of the genetic distance among native American peoples suggests that there are four groups that have been isolated for a relatively long period of time. He concludes that there were four separate migrations.

All this disagreement prompts Greenberg to simply ignore the new mtDNA data. He says: "Every time, it [mtDNA] seems to come to a different conclusion. I've just tended to set aside the mtDNA evidence. I'll wait until they get their act together."

Even some geneticists are reluctant to claim they have solved the problem of the peopling of the Americas. "I am worried that too much weight is being given to mitochondrial DNA," says Stanford University geneticist Luigi Luca Cavalli-Sforza. He notes that mtDNA reflects only the movements of women. Because women in some hunter-gatherer societies join their husbands' families and move more than men, their mtDNA may not reveal the migrations of the whole population. So Cavalli-Sforza and colleague Peter Underhill, as well as other teams, are studying markers on the paternally inherited Y chromosome. So far, their results don't rule out additional migrations.

Indeed, researchers warn that more data from several genetic lineages will be needed to provide a picture of the peopling of the Americas. However, that time may not be so far off. One of the other authors of the Greenberg hypothesis, University of Arizona geneticist Stephen Zegura, is taking the new studies seriously and has taken a sabbatical this year to try to sort out the findings: "I'm trying to decide if after 10 years, is the time right to do a new synthesis?" The answer from a new wave of young geneticists, at least, is a resounding yes.

–Ann Gibbons

ARCHAEOLOGY

Art Stirs Uproar Down Under

SYDNEY MORNING HERALD/REX FEATURES

Circling in on the dream time. Ancient dates for Australian rock art have sparked a furor among anthropologists.

It was almost the archaeological equivalent of finding life on Mars. Two weeks ago, what could be the biggest archaeological news in decades erupted from the northern Australian outback, with reports of an ancient site that puts humans on the continent between 116,000 and 176,000 years ago—up to three times as far back as most previous estimates. And the team of Australian researchers also found examples of rock art—small circular carvings—that they dated to about 60,000 years old, more than 20,000 years older than the most ancient known art of this kind.

Because most anthropologists believe that modern humans did not leave Africa until 100,000 years ago, these dates, if confirmed, would force a massive revision of human history. "If it could be demonstrated [that] people were in Australia more than 100,000 years ago, we would have to rethink everything we thought we knew about the later phases of human evolution," says Stanford University paleoanthropologist Richard Klein.

But that's a big if. The significance of the site hinges on its age, and many scientists are skeptical about the dating, which was done with a relatively new technique called thermoluminescence (TL). "Unbelievable," says archaeologist John Beaton of the University of California, Davis. "These dates are wildly out of line with everything else we know." Even archaeologist Rhys Jones of the Australian National University in Canberra, who last year made waves by dating two other Australian sites to 60,000 years with the same method (*Science*, 31 March 1995, p. 1908), warns that until more tests have been done, "we do not know how valid the present TL claims are."

The big news came out in a rather unorthodox fashion: A paper on the find was scheduled for the December issue of the British journal *Antiquity*. But editor Christopher Chippindale says someone at the Australian Museum in Sydney inadvertently leaked the story, and on 21 September the *Sydney Morning Herald* trumpeted the discovery of an "outback Stonehenge that will rewrite our history." *The New York Times* followed the next day, boldly asserting that the find held "signs of artists who predate *Homo sapiens*." The authors of the forthcoming paper—anthropologist Richard Fullagar of the Australian Museum, and Lesley Head and David Price of the School of Geosciences at the University of Wollongong in New South Wales—have been fielding a hail of phone calls, faxes, and e-mails ever since.

The paper describes a rocky site in the Kimberly area of northwestern Australia that is known to the local aborigines as Jinmium. There, Fullagar's team found buried artifacts, including pieces of ochre and tools made from carved rock, plus thousands of circles, all about 3 centimeters across, carved into boulders. The team dated the sediments with TL, which involves measuring electrons trapped in defects in quartz crystals; these electrons accumulate at a regular rate but are "bleached" out of the crystal by sunlight, so that the "clock" starts at zero when a sample