Tracing the Road Down Under

SYDNEY, AUSTRALIA—Fifty human-origins researchers gathered here at the University of New South Wales from 29 to 30 September. The genetic, archaeological, and environmental data they presented sketches a new picture of the colonization of Australia by both humans and canines.

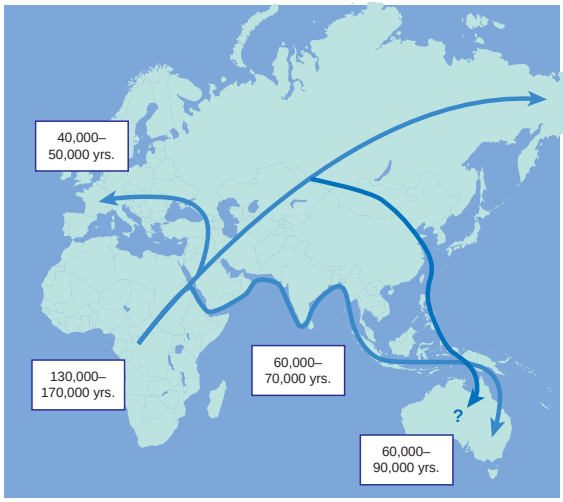
For millions of years, Australia was chiefly a marsupial playground, home to killer kangaroos, giant wombats, and tigerlike carnivores—but not to people. Humans and their commensals finally arrived sometime in the last 100,000 years or so, but researchers have argued heatedly over exactly when. Most experts plump for about 40,000 years ago, whereas a splinter group argues for an early arrival at least 60,000 years ago, probably from several parts of Asia.

At the meeting, researchers presented new genetic and paleoecological evidence that has the warring parties edging a bit closer to agreement. This emerging view sees early Australians arriving on the continent perhaps as much as 60,000 years ago and reaching widespread occupation 15,000 years later. Like immigrants today, settlers may have come via two routes, one along the coast of Arabia, India, and south Asia and another down from China and central Asia. "This work sounds exciting," says Chris Stringer, head of the human origins group at the Natural History Museum in London. "Such an age [for colonization] would not surprise me."

The sharp disagreement about when humans arrived in Australia stems from the wide range of dates yielded by different techniques, sometimes for the same bit of bone. For example, the age of Australia's oldest known human remains, a skeleton known as "Mungo Man," has been set by various techniques at between 40,000 and 68,000 years, with the most recent work pointing to 42,000 years. Dating expert Ed Rhodes of Australian National University in Canberra plotted all the dates from fossils and artifacts associated with early Australians and concludes that, based on the very limited existing data, the "best fit" is that people first arrived 45,000 to 48,000 years ago. "It may be earlier, but there's not enough data" to be certain, he said in Sydney.

The paleoecological data, however, fit a scenario of even earlier arrival, with widespread occupation by 45,000 years ago, according to paleoecologist Peter Kershaw of Monash University in Melbourne. He analyzed data from seven deep land and marine cores from in and around Australia, which offer a continuous, 300,000-year record of pollen and charcoal. Charcoal peaks are associated with fires, and Kershaw spotted two, at 45,000 and 130,000 years ago. He attributes the 45,000-year peak to widespread human activity. "The earlier peak is most easily explained by climate change, but an early arrival is possible," he says.

Genetic evidence presented in Sydney also tends to support an early arrival, as well as providing clues to the routes taken. Molecular anthropologist Sheila van Holst Pellekaan, of the University of New South Wales and Sydney University, and Oxford University population geneticist Rosalind Harding compared mitochondrial DNA (mtDNA) from 188 Aboriginal people from remote parts of Australia to 61 mtDNA samples from people around the world. According to van Holst Pellekaan, preliminary analysis reveals three "very ancient" sets of mutations, called haplogroups, that are distinctive to Australia. Some variations within one haplogroup are shared by people living along a geographic line from southern India and southeast Asia, thus suggesting a migration route. Likewise, some variations within the other haplogroups are shared predominantly with people along a line originating in China and Indonesia. The findings imply a two-pronged entry, although that needs confirmation, says van Holst Pellekaan.



Road map. Mitochondrial DNA data suggest these routes and times for human expansion out of Africa.

As for timing, "Sheila wouldn't put a date on it, but I will," says Harding. She argues that the steadily ticking "molecular clock" traditionally used by geneticists is unrealistic and produces ages that are too young. Instead, Harding uses random mutation rates, which she claims more accurately reflect the natural world. Assuming two different rates, Harding concludes that the ancient haplogroups arose either 60,000 or 90,000 years ago, suggesting an arrival in Australia well before 40,000 years ago.

Other researchers also turned up some evidence for a route through India. Geneticist Rodney Scott of the University of Newcastle and John Hunter Hospital in New South Wales and his colleagues compared differences in genes coding for cytokines—cells that regulate an inflammatory response to infection—in 118 Aborigines from Australia's Northern Territory, 262 Britons and European Australians, and 32 Bangladeshi. They found that the genotypes rare in Aborigines were common in Britons and European Australians, and vice versa, with the Bangladeshi results in the middle. "The results suggest a gene flow across the Indian subcontinent towards Australia," concludes Scott, although he adds that the work is preliminary and must be confirmed.

Molecular anthropologist John Mitchell of La Trobe University in Melbourne, who has tracked human migration through the Y chromosome, says the findings presented in Sydney make sense in terms of both timing and route. "This is definitely what the Y chromosome data show," says Mitchell, referring to work he published in 1999 in *Human Biology*. Despite the lingering disparity over dates, he says, "overall, a pattern is clearly emerging."

On the Trail of the First Dingo

Australia's national dog, the dingo, is famous for its wolflike howls and wild ways. But new genetic work suggests that all of today's feral hounds are descendants of an ordinary domestic pooch from the islands of Southeast Asia. And although dingoes have spread across the continent, their ancestors arrived Down Under in a single introduction roughly 5000 years ago, says molecular biologist and geneticist Alan Wilton of the University of New South Wales in Sydney.

"The founding event was small," says

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Gone wild. Once domesticated, the dingo went feral after reaching Australia.

Wilton, who presented the work. "It may have been one pair or a group of closely related dogs. It may even have been a single pregnant dog."

The new study is "very convincing and thorough," says evolutionary biologist Robert Wayne of the University of California, Los Angeles, an expert on the domestication of the dog. "It really suggests there was a single founding event."

Until now, dingo DNA had not been studied for clues to the dog's origins, and their fossil record is sparse. The earliest documented fossils are a mere 3500 years old, and dingoes never reached the island of Tasmania, which was separated from the mainland by sea level rise 12,000 years ago. Thus experts had concluded that the dog arrived between 3500 and 12,000 years ago, most likely about 5000 years ago—long after dogs were trotting after their humans in most of the rest of the world.

Wilton and his colleagues, including Peter Savolainen of the Royal Institute of Technology in Stockholm and others in Sweden and New Zealand, compared a 582-base-pair stretch of noncoding mitochondrial DNA (mtDNA) in 211 dingoes from across Australia, 676 dogs from around the world, 38 Eurasian wolves, and 19 pre-European dog fossils from Polynesia. They discovered that "all dingoes have a very similar type of DNA," says Wilton. "Any variation is only a single mutation away from the main type." That profound homogeneity shows that the founding population must have been just a few dogs, he says. Assuming a steady mutation rate, the team estimates that all the dingo mutations did indeed arise in the past 5000 years.

Combining these results with previous work, Wilton can sketch dingo history. Last year, in a study on the origin of domestic dogs, Savolainen and colleagues showed that dogs were first domesticated from wolves in East Asia about 15,000 years ago (*Science*, 22 November 2002, p. 1610). In the new study, Wilton found the dingo "main type" in some dogs in East and Southeast Asia, Siberia, Japan, and the Indonesian archipelago. "Have you ever seen a New Guinea Singing Dog? It's a dingo with stumpy legs," jokes Wilton. Thus he suggests that the ancestor of the dingo and its cousins appeared in China 10,000 to 15,000 years ago and was brought south by people, with Indonesia as the last port of call. "Australia was the end of a long chain of migration," he says. Still, he notes that some dingoes must have been taken back to Indonesia in the early days, because some Indonesian dogs have lice and parasites that evolved in kangaroos.

Unfortunately for romantics, the team found that wolves—the original wild dogs—do not carry the dingo main type. That scotches the notion that the dingo too had wild roots. Instead, the wild behavior seen today developed because the original domestic mutts went feral soon after they were brought to Australia, says Wilton.

Dingo lovers may be relieved to know that despite their domestic beginnings, dingoes are still special: They're a unique remnant of an early, undifferentiated dog. "Dogs were just dogs then," says Wilton. "Breeds are a fairly new thing."

But the dingo's unique gene pool may be vanishing, thanks to inbreeding with modern dogs. Already 80% of dingoes along the Australian east coast are hybrids, and no programs are in place to isolate "pure" dingoes in the wild, says Wilton. "It gets worse all the time," he claims. "They may be extinct in 50 years." **–LEIGH DAYTON**

Leigh Dayton writes from Sydney, Australia.

Molecular Electronics

Next-Generation Technology Hits an Early Midlife Crisis

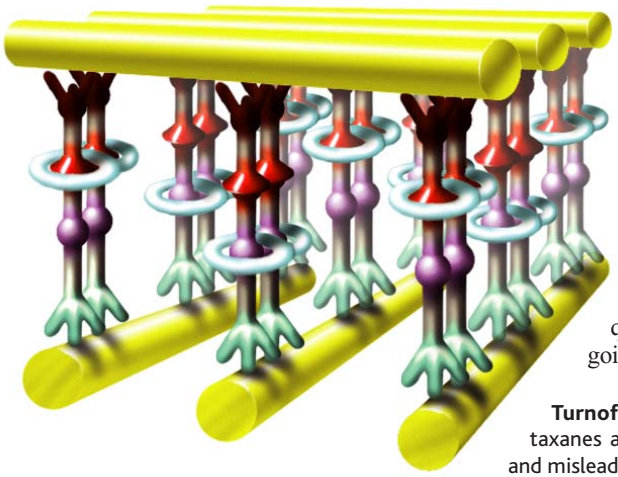
Researchers had hoped that a new revolution in ultraminiaturized electronic gadgetry lay almost within reach. But now some are saying the future must wait

Two years ago, the nascent field of molecular electronics was riding high. A handful of research groups had wired molecules to serve as diodes, transistors, and other devices at the heart of computer chips. Some had even linked them together to form rudimentary circuits, earning accolades as *Science*'s 2001 Breakthrough of the Year (*Science*, 21 December 2001, p. 2442). The future was so bright, proponents predicted that molecular electronics–based computer chips vastly superior to current versions would hit store shelves in 2005.

Now, critics say the field is undergoing a much-needed reality check. This summer, two of its most prominent research groups revealed that some of their devices don't work as previously thought and may not even qualify as molecular electronics. And skeptics are questioning whether labs will muster commercial products within the next decade, if at all.

"There are a number of parts of the field that really weren't critically tested before being publicized and published. So people are having to backpedal," says Paul Weiss, a chemist at Pennsylvania State University, University Park. Adds chemist Jim Tour of Rice University in Houston, Texas, who has been one of the field's most vocal proponents: "I'm surprised it took this long to have some things confronted."

At the top of that list, Tour and others say, are questions of exactly what is going on at the heart of some de-



Turnoff. Models like this one for rotaxanes are "somewhere between naïve and misleading," Paul Weiss says.

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