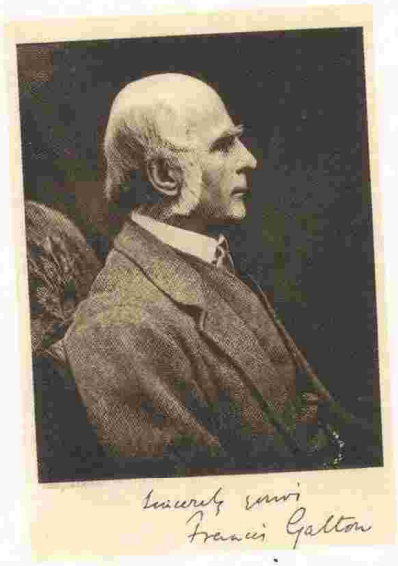


Francis Galton's dealings with the Damara tribe (below) shaped later evolutionary theories

An eminent Victorian's powerful traveller's tales sparked a hunt for the roots of mathematics whose legacy lingers to this day, says historian of science **Michael Barany**

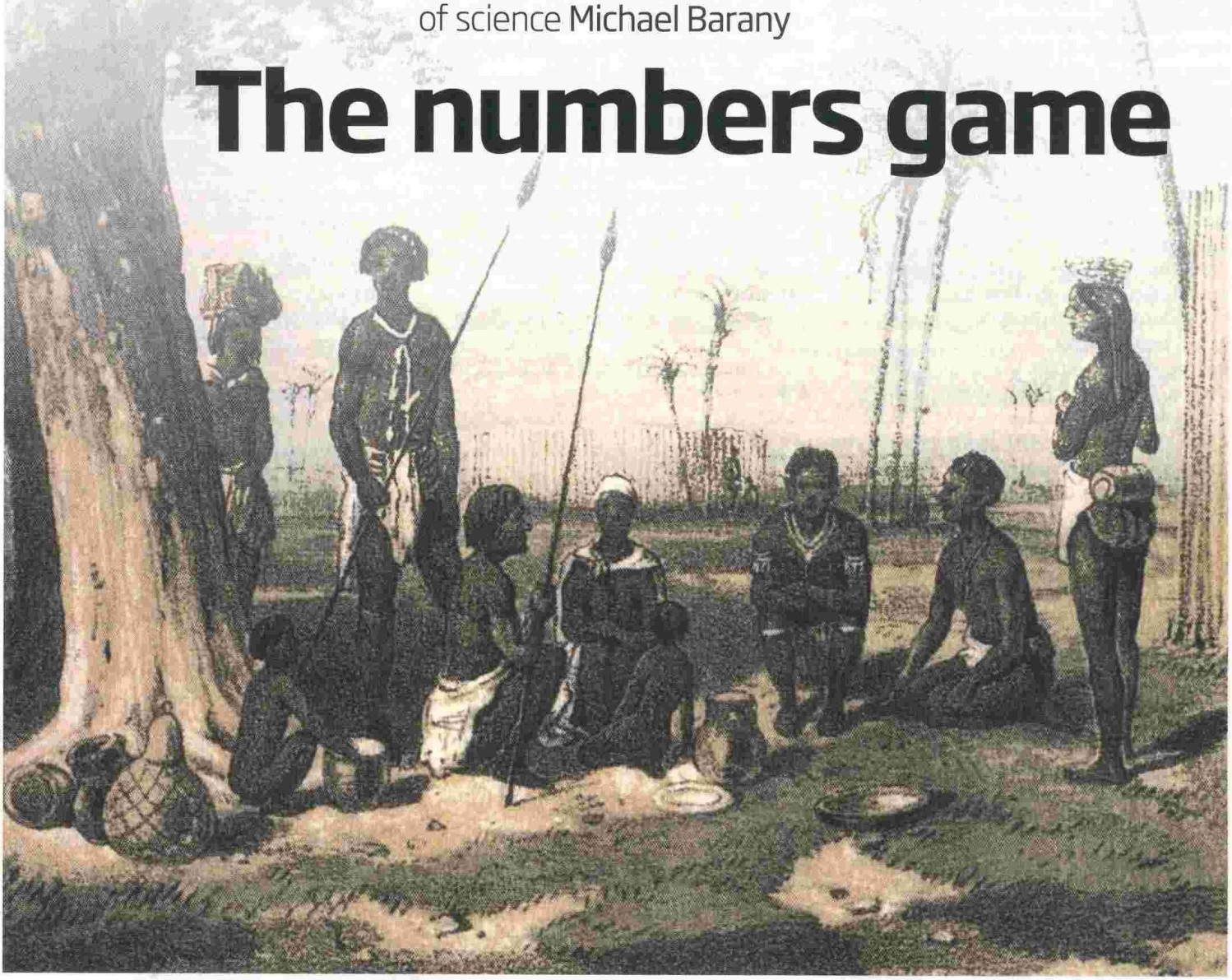
The numbers game

LOOKING back, Francis Galton would call it "our most difficult day". It was 4 March 1851, and the young English explorer was beginning to appreciate the obstacles confronting his attempts to map out the Lake Ngami region of south-western Africa. Struggling to navigate a narrow ridge of jagged rock, his wagon had "crashed and thundered and thumped" while his oxen "charged like wild buffaloes".

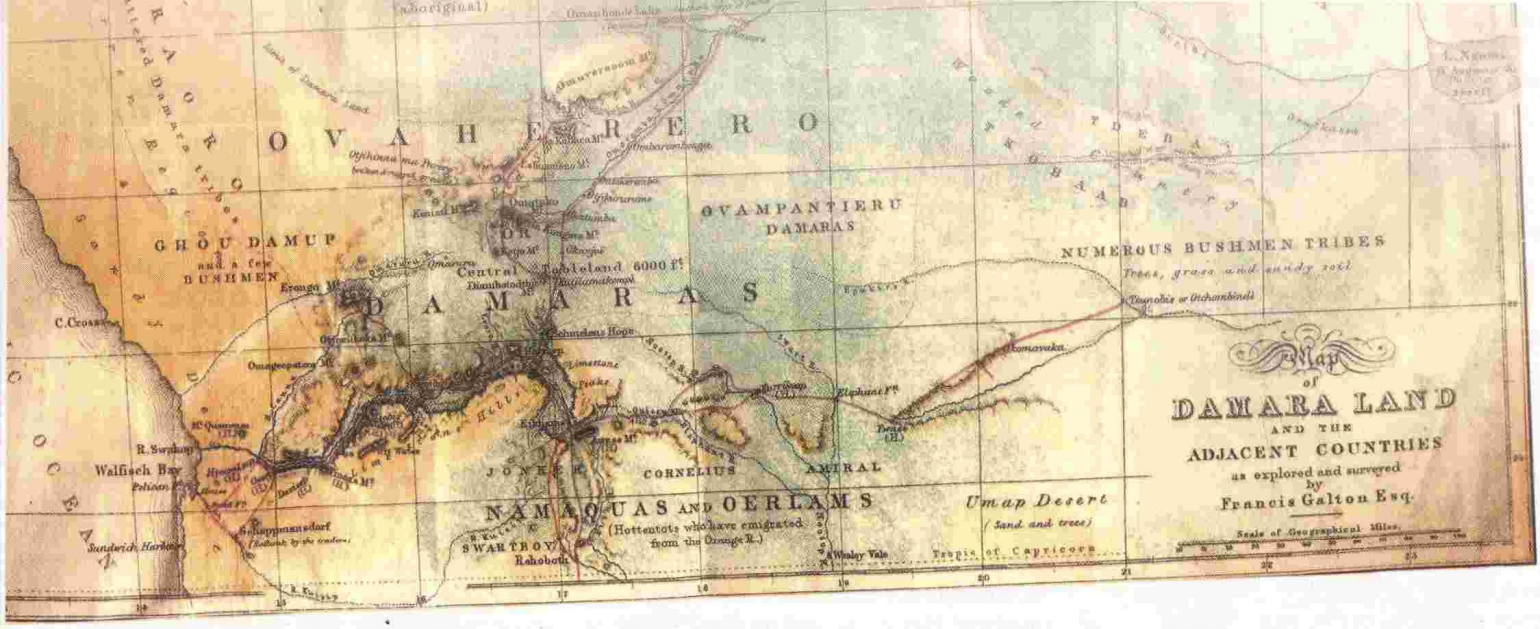
To make matters worse, Galton had little faith in his local guides from the Damara tribe, who appeared to lack even an understanding of basic arithmetic – a situation Galton found "very annoying". He recounts that having established an exchange rate of one sheep for two sticks of tobacco, he handed four sticks to a local herdsman in the expectation of purchasing two sheep. Having put two sticks in front of the first sheep, the man seemed surprised that two sticks remained to pay for the second. "His mind got hazy and confused," Galton reported, and the transaction had to be abandoned and the sheep purchased separately.

As further evidence of the apparent ignorance of the Damara, Galton wrote that they "use no numeral greater than three" and that they managed to keep track of their oxen only by recognising their faces, rather than by counting them. At a most inopportune time for his expedition, Galton seemed to have stumbled into a world without numbers.

To a modern reader, these tales in Galton's 1853 *Narrative of an Explorer in Tropical South Africa* seem little more than pithy anecdotes that reflect his prejudices as a gentleman of the growing Victorian empire. (His preoccupation with the supposed inferiority ›



NARRATIVE OF AN EXPLORER IN TROPICAL SOUTH AFRICA



Galton's attempts to map Lake Ngami were beset by communication problems with the locals

"Among Galton's many fans, his cousin Charles Darwin wrote to profess 'how very much I admire the spirit and style of your book'"

of other peoples persisted in his later work in eugenics.) Within 10 years, however, those same reports of primitive innumeracy were being used by the finest scientific minds of Victorian Britain to glimpse the savage condition of prehistoric humans.

The reports' influence did not stop there. As I have traced this trend over the ensuing decades, it has become clear just how important these speculations were in shaping the anthropological study of numbers, with ramifications for psychology, linguistics and the philosophy of mathematics. Its legacy still lingers, 100 years after Galton's death. So just how did his account become so central to such a broad swathe of 19th-century science?

Narrative of an Explorer in Tropical South Africa initially launched Galton to prominence as an explorer and travel writer, thrilling readers with tales of strange worlds occupied by ignorant peoples. Among his many fans, his cousin Charles Darwin wrote to profess "how very much I admire the spirit and style of your book". He became the toast of the Royal Geographical Society, though few scientists at that point read his tales for anything more than entertainment.

All that would change in 1859. In September of that year, leading geologist Sir Charles Lyell addressed the British Association for the Advancement of Science at its annual meeting in Aberdeen. Lyell had been prominent among those who were sceptical of the idea that humans may have roamed the Earth tens or even hundreds of thousands of years ago, but that day he finally declared before a rapt audience "that the date of man must be carried further back than we had heretofore imagined". Among his evidence, Lyell cited a forthcoming book that would become one of the most influential tomes ever written: Darwin's *On the Origin of Species*.

Almost overnight, the field of prehistory was born. Britain's leading scientists raced to discover how humans had evolved from primitive cave dwellers to the species that included intellectuals like Newton and Darwin. Some looked to fossils and stone tools for their evidence, but these were in short supply and difficult to interpret, so many instead turned to the study of present-day peoples. By examining those least influenced by advanced civilisations, they argued, one could identify traits common to all societies and determine how they evolved.

Compelling tales

Numeracy looked like the perfect starting point. Explorers, missionaries, merchants and colonists alike needed to exchange numerical information with the people they encountered; when compiling dictionaries and reports of strange languages and peoples, numbers could hardly be avoided. Personal anecdotes proved particularly helpful for scientists trying to imagine how a society could do without numbers, and none were more widely read and lauded than Galton's, whose writings were quoted in nearly every significant work on numbers in prehistoric societies in the decade after Lyell's speech.

Why Galton? Though his writing was full of inconsistencies, and he was prone to exaggeration, his tale was quick, amusing, suggestive, flexible and popular. This made him a towering figure in the prehistory of counting, without him ever intending to be one.

Daniel Wilson, a professor at University College in Toronto, Canada, and John Crawfurd, the president and chair of the Ethnological Society of London, were two of the earliest figures to turn to Galton's accounts, both within three years of Lyell's speech. They were swiftly followed by John Lubbock, the English banker and naturalist who popularised the term "prehistory" in Britain.

For Lubbock, numbers were definitive proof that societies had developed on a path of ever-increasing intelligence. After all, once a group could count to 10 it seemed impossible for them to "unlearn a piece of knowledge so easy and yet so useful". To illustrate the low end of the scale, Lubbock quotes Galton's reports of the Damara in both *Prehistoric Times* of 1865 and *The Origin of Civilisation* of 1870. The tale, he wrote, is "so admirable" and "so amusing" that he "cannot resist quoting it in full".

Lubbock proved to be influential in establishing the study of so-called "savages" as a promising line of inquiry. In a review of *Prehistoric Times* for the fourth issue of *Nature* (vol 1, p103), comparative anthropologist and linguist Edward Burnett Tylor declared that "the condition of mankind in the remote antiquity of the race is not unfairly represented by modern savage tribes".

Tylor's own account of humanity's evolution, his 1871 *Primitive Culture*, turned out to be even more important. In the book, he laid out a complex scientific argument about the progressive development of language, religion and culture, while numeracy provided him with a benchmark for comparing different peoples, as well as a model for his general method of analysis. Tylor's views

caught the attention of many high-profile figures: Darwin, for instance, approvingly cited the work in his account of human evolution in *The Descent of Man*.

Tylor's work was enormously influential on many fronts, including the question of how numeracy itself evolved. He aimed to prove the widely shared view that hands and fingers must have been crucial in the development of counting. The earliest societies, he posited, might distinguish the one from the many, often with a separate word for "two". Anything else would be signalled with gestures, or vague words that meant "many". Galton's Damara, for example, who were barely past this stage, used fingers "as formidable instruments of calculation" to indicate greater numbers.

Gradually, however, hands became not just a practical but also a symbolic way of representing numbers. As evidence, Tylor cites three common counting systems in the "uncivilised" cultures – the quinary system of base 5 (using one hand), the decimal system of base 10 (using both hands) and the vigesimal system of base 20 (using both hands and feet). "The tendency of the higher nations," he concluded, "has been to avoid the one as too scanty, and the other as too cumbrous, and to use the intermediate decimal system."

Other accounts soon followed in a similar vein. Among them was Connecticut historian James Hammond Trumbull's exhaustive 1874 report for the American Philological Association on the number systems of North American Indians, in which he meticulously identified linguistic links between numbers and the names of particular body parts. The work persisted well into the 20th century as a standard reference on the topic.

Eventually, numeracy became so closely associated with human evolution that it was used to theorise about other features of our prehistory. Australian amateur anthropologist Edward Micklethwaite Curr, for example, spent a decade collecting vocabulary lists from across the Australian continent. His work, published in 1886, suggested that Australian Aborigines must have migrated from Africa in the distant past, since many Africans had since learned to "count as high as thousands", while native Australians could not count past 3.

John Lubbock became famous for his work on biology

By today's standards, Curr's work seems deeply unscientific. His conclusion that Australians could not count past 3, for instance, was based on word lists that included only numbers up to 4 – the last of which Curr assumed "means any number over 3". Thanks to Galton and his successors, Curr "knew" that primitive peoples were unable to count, so why waste energy researching it further?

By the end of the 19th century, scholars wrote whole books reviewing the anthropological and linguistic study of numbers, though stories like Galton's were already fading in importance. The expanding reach of colonisation and trade made it harder to find societies untouched by outside civilisation. Meanwhile, other sources of evidence had begun to become more central, including the study of children, animals, and the increasing body of archaeological finds.

Yet the ideas have lingered, influencing many areas of science. Tylor's accounts of primitive peoples counting on their fingers, for instance, figured in early theories of child development that drew on historical speculations to explain how children begin to learn the concept of number using their digits. Susan Cunnington, an educator in the early 1900s, summarised the viewpoint best: "In the nursery and the school we may see, writ small, the story of long ages of the human race." Traces of this can even be found in the seminal work of Jean Piaget.

Today, we are still attempting to understand the origins of numeracy, using whatever methods are available. Some researchers look to comparatively less-educated members of their own societies to try to discover our innate mathematical skills. Thus, studies of deaf "homesigners" in Nicaragua, who have developed sign languages without signs for precise numbers, argue that the ability to use exact numbers above 3 relies on a linguistic numerical system (*Proceedings of the National Academy of Sciences*, vol 108, p 3163).

Others are taking an approach that is even closer to Tylor's methods. Some present-day Amazonian tribes such as the Mundurucú, which many linguists and psychologists believe lack number words beyond 5, may offer the closest parallel to the Galton's Damara, and these innumerate peoples are again being studied in the hope of identifying universal characteristics of human cognition. One recent study, for example, argues that without the use of symbols or counting words, humans tend to compare quantities logarithmically, in terms of their rough ratios, rather than linearly, based on the strict numerical difference (*Science*, vol 320, p 1217). When asked to represent various quantities of dots on a number line, for example, the Mundurucú will put 5 much closer to 10 than 1, since 10 is only twice as big as 5, but 5 is five times as big as 1.

As for Galton's story of the Damara, it is now rarely quoted in the way that Lubbock and his peers once used it, though it continues to crop up as an anecdotal aside.

With this legacy, you may wonder whether Galton ever returned to the subject himself. He lived long enough to have seen his story figure in decades of scientific argument, yet despite his many connections to the leading scholars of prehistory, he never took part in their debates. His research moved instead to other matters, like statistics and the roles of nature versus nurture in our development, ultimately turning to the eugenic betterment of his race. While others were preoccupied with human civilisation's past, Galton's eyes were squarely on his vision of its future. ■

"Though Galton's writing was full of inconsistencies, and he was prone to exaggeration, his tale was quick, amusing, suggestive, accessible, flexible and popular. This made him a towering figure in the prehistory of counting, without him ever intending to be one"

Michael Barany researches the history of science at Princeton University. He has submitted his latest work to the *British Journal for the History of Science*.