cal details don't add up. Instead of the open x-line configuration of Fig. 2a, the theory of simple magnetized fluids predicts a macroscopic magnetic 'nozzle' as shown in Fig. 2b. In this picture, the rate of energy release is limited by the speed at which plasma, and the magnetic field associated with it, can flow into the x-line region. Like water in a hose, the flow of plasma into the nozzle is limited by how fast the plasma flows out of the nozzle. But the maximum velocity that the outflowing plasma can reach is the Alfvèn velocity. Because the outflow velocity is fixed, if the length of the nozzle in Fig. 2b is doubled, the inflow velocity is halved. So because the magnetic nozzle is very long and narrow, the inflow of plasma is severely limited and the rate of magnetic energy release is very slow. Sweet[4] and Parker[5] first proposed the theory behind this magnetic nozzle in the 1950s, and modern computer simulations confirm the basic finding. The problem is that the slow rates of energy release predicted by this theory are inconsistent with the explosive events seen in nature and in the laboratory.

This dilemma has been resolved in recent years as theorists re-examined the assumptions behind the simple magnetized fluid, or 'magnetohydrodynamic', picture of reconnection. The breaking of the magnetic field lines actually takes place in a narrow region around the x-line of Fig. 2a. In this narrow region the magnetohydrodynamic description fails: instead of the electrons and protons moving together, as predicted by the magnetohydrodynamic model, the two species move independently. As a result, a new class of plasma waves called whistlers is generated, which can accelerate electrons to much higher velocities in a localized region near the x-line. As the name implies, these waves were first heard by radio operators as a falling tone — the wave velocity varies inversely with the wavelength, so short-wavelength, high-frequency waves reach the operators first. The acceleration of outflowing electrons to very high velocities by the whistler wave bypasses the bottleneck created by the magnetic nozzle in Fig. 2b and restores the open x-line of Fig. 2a, with its explosive rates of magnetic energy release.

The characteristic signature of a whistler wave is the generation of magnetic field components in and out of the plane shown in Fig. 2a. Confirming the existence of these field components around the x-line is a key test of the whistler theory. In earlier laboratory experiments on magnetic reconnection, Stenzel and Gekelmann[8] measured the out-of-plane magnetic fields. But Deng and Matsumoto[1] report the first measurements of these fields in a natural environment — from data taken by the Geotail satellite at the magnetopause, the boundary between the incoming solar wind and the Earth's magnetosphere. The data are tantalizing because the character of the magnetic field components seems to match exactly the theoretical

predictions. More detailed measurements, especially of electron and ion flows, are required to make a compelling case that the theory is valid. The proposed NASA Magnetospheric Multiscale Mission is being designed to tackle these issues by using a cluster of satellites to obtain a complete picture of magnetic reconnection.

The emerging theory of magnetic reconnection seems to offer an explanation for the fast release of magnetic energy, but leaves many mysteries unsolved. Why do the magnetic fields remain apparently quiescent for long periods of time and then suddenly explode for no apparent reason? This behaviour is seen in the solar corona, the magnetosphere and laboratory plasmas. The spark that ignites the release

process is still poorly understood. So, despite the large steps taken to unravel one of the biggest puzzles in plasma physics, the drama in our skies will demand further investigations. ∎

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Palaeoanthropology

Our newest oldest ancestor?

Leslie C. Aiello and Mark Collard

These are exciting times in the study of human origins. But excitement needs to be tempered with caution in assessing the claim of a six-million-year-old direct ancestor of modern humans.

Last month a team of French and Kenyan researchers, led by Brigitte Senut and Martin Pickford, published their discovery of 12 fossils, including fragmentary thigh and arm bones as well as several teeth, that they claim belong to a previously unrecognized genus and species of human ancestor[1,2]. Originally dubbed 'Millennium man' or 'Millennium ancestor', these fossils come

from the Lukeino Formation of the Tugen Hills in Kenya. Together with an enigmatic lower left molar discovered in the 1970s, they have now been given the formal name *Orrorin tugenensis*[1].

The announcement of *Orrorin* has caused a considerable stir. This is partly because the fossiliferous deposits of the Tugen Hills are being prospected by two competing groups
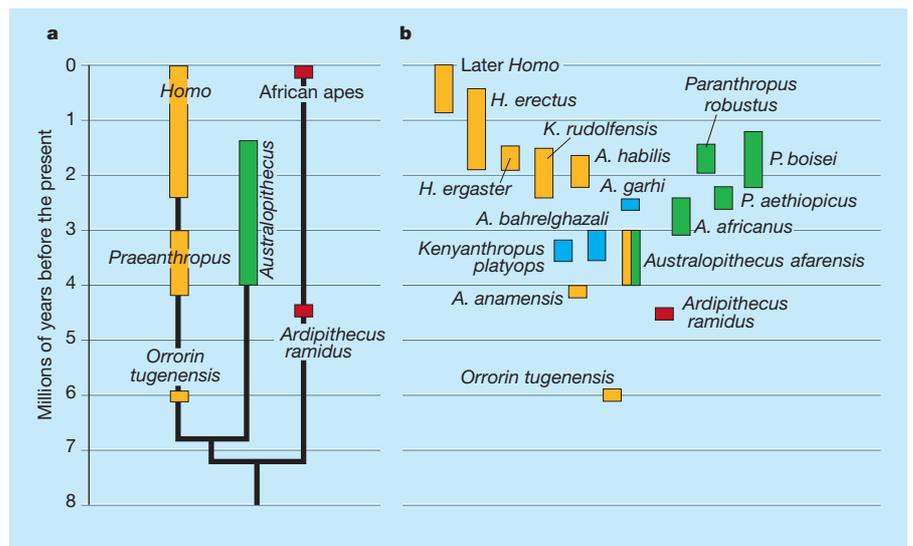

Figure 1 **Hominins old and new.** a, **The evolutionary relationships proposed by Senut and colleagues[1,9]. Here, the newly described *Orrorin tugenensis* is on the direct line leading to modern humans (yellow), and *Ardipithecus ramidus* is an ancestor of the African apes (red). *Kenyanthropus rudolfensis* (previously *Homo rudolfensis*) is not shown here but is included in the *Orrorin/Praeanthropus/Homo* lineage[9].** b, **The known species diversity in the hominin fossil record. The species *Kenyanthropus platyops*, *Australopithecus garhi* and *A. bahrelghazali* (blue) are either too recently described or too fragmentary to have been considered by Senut and colleagues.**

of researchers[3,4], but primarily because *Orrorin* is claimed to be about 6 million years old. This makes it 1.5 million years older than *Ardipithecus ramidus*[5], the oldest previously recognized candidate for the earliest hominin. (Hominins include modern humans and fossil species more closely related to them than any other living species.) Significantly, *Orrorin*'s age falls within the molecularly determined range of the last common ancestor between humans and the African apes (8–5 million years ago). The authors also argue that *Orrorin* is on the direct line leading to modern humans, whereas most of the members of the genus *Australopithecus* are not (Fig. 1a). Furthermore, they reposition *Ardipithecus* as an ancestor of the African apes, rather than as the first known human ancestor.

The great age of *Orrorin* does not seem to be in serious question. The geology of the Lukeino Formation is well known[2]; the volcanic tuffs in this formation have been securely dated at 6.2–5.6 million years old by radiometric techniques[6]; and there is little doubt that the specimens come from the Lukeino Formation sediments[2]. It is difficult, though, to have the same confidence in Senut and colleague's conclusions about human evolutionary history. They adopt a simple two-branch evolutionary tree for the hominins (Fig. 1a). One branch leads from *Orrorin* to *Homo* through the novel intermediary genus *Praeanthropus*; the other leads to *Australopithecus* and extinction. This simple phylogeny contrasts starkly with mainstream ideas about human evolution, and glosses over many areas of controversy and uncertainty.

The picture is further complicated by last week's announcement of yet another new hominin genus and species, the 3.5–3.2-million-year-old *Kenyanthropus platyops* from West Turkana in Kenya[7,8]. At least 13 known hominin species from Africa existed before *Homo erectus*, and this period of our evolutionary history now looks more like a tangled bush than a simple tree (Fig. 1b). There are only a few points of consensus among most palaeoanthropologists. One is that there are four hominin genera (*Ardipithecus*, *Australopithecus*, *Paranthropus* and *Homo*), with the new *Kenyanthropus* making five. Another is that the big-toothed and massive-jawed genus *Paranthropus* (*P. aethiopicus*, *P. robustus* and *P. boisei*) represents a dead-end branch of the bush.

To understand Senut and colleagues' interpretation of *Orrorin* it is necessary to appreciate their reasons for creating an additional hominin genus, *Praeanthropus*. Senut has long believed that the skeleton, and not the skull and teeth, is the best guide to hominin evolutionary relationships[9]. She argues that the skeletal evidence suggests a very old division in hominin locomotor ability. One lineage, characterized by climbing and bent-legged bipedal walking, led to most

of the members of the genus *Australopithecus* (including *Paranthropus*); the other lineage, comprising straight-legged walkers, led from other members of the genus *Australopithecus* through *Praeanthropus* and *Homo rudolfensis* (now *Kenyanthropus rudolfensis*[7]) to *Homo sapiens*. The genus *Praeanthropus* represents those members of the genus *Australopithecus* that Senut interprets as having a skeleton suggesting more modern walking (*A. anamensis*, and some fossils normally included in the species *A. afarensis*)[9]. She also suggests that this phylogeny is supported by evidence from the teeth and jaws.

Most palaeoanthropologists do not recognize a major dichotomy in hominin locomotor ability before the evolution of *Homo ergaster*, around 1.9 million years ago, and recent analyses of the *A. anamensis* skeleton suggest that it was much like that of other members of the genus *Australopithecus*[10,11]. Senut's claim for more modern walking for *Orrorin*, linking it with *Praeanthropus* and *Homo*, is based on detailed aspects of the anatomy of the upper part of the thigh-bone that are open to alternative explanations. For example, she and her colleagues argue that the head of the thigh-bone is very large and human-like in relation to the size of the neck of the bone. This is true, but it is also the case that *Orrorin* is no more similar to *Praeanthropus* in this feature than it is to *Australopithecus*, which also falls within the human range of human variation.

Senut and colleagues claim[1] that *Orrorin*'s relatively small, thick-enamelled molars support their interpretation that *Orrorin* is a direct ancestor of modern humans to the exclusion of *Ardipithecus* and most members of the genus *Australopithecus*. But tooth size and enamel thickness correlate with diet[12]: in the absence of other compelling evidence to link *Ardipithecus* with the African apes, or *Orrorin* with humans, it is premature to make such bold claims.

The age of *Orrorin* undoubtedly makes it a highly important addition to the debate about human origins. But we are a long way from a consensus on its role in human evolution. There are many alternative hypotheses that are equally defensible, including some in which *Orrorin* is not a hominin. *Kenyanthropus* and other new, and as yet little known, hominins such as *Australopithecus garhi*[13] introduce further uncertainty. It also appears that cranial and dental anatomy does not necessarily mirror molecularly determined phylogenies in modern primates[14], which casts considerable uncertainty on anatomically based evolutionary trees. For now, at least, it is probably best to avoid naming ancestors, and maintain a simple division: that between hominins of archaic aspect (*Orrorin*, *Ardipithecus*, *Australopithecus* — including *Paranthropus* — and *Kenyanthropus*) and hominins of modern aspect (*Homo sapiens* and the remaining species of *Homo*)[15,16]. ∎

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Neurobiology

Cannabinoids act backwards

MacDonald J. Christie and Christopher W. Vaughan

Cannabis is useful for treating many ailments, but has unwanted side effects. Drugs that control signalling by cannabinoids found naturally in the body might be more useful.

Preparations from the plant *Cannabis sativa* have been used since antiquity, not only for their intoxicating effects, but also to treat a number of ailments[1,2]. The main active component of these preparations, Δ^9-tetrahydrocannabinol, produces most of its effects on the central nervous system by interacting with specific cannabinoid receptors on nerve cells. Under normal circumstances, these receptors are thought to

be one element of a neurotransmitter system that controls neuronal excitability. Other components of this putative signalling system include cannabinoids that are found naturally in the body, as well as cellular mechanisms by which these 'endocannabinoids' are synthesized, transported and metabolized[3]. But it has not been clear how important this system really is, because of a lack of direct evidence for the synthesis,