EVOLUTIONARY BIOLOGY

The path to sociality

A comparative analysis traces the trajectory of change in social organization among primates and establishes a firm foundation for modelling the origins of social complexity. SEE LETTER P.219

JOAN B. SILK

Recent discoveries related to human origins — from new fossils to ancient DNA — have stirred intense interest from scientific journals and the popular media. But perhaps more intriguing are the intimate lives of our distant ancestors. Although the steamy details may be shrouded in the mists of time, some hints about the sequence of events that led to the evolution of human social systems are emerging. The latest evidence comes from Shultz *et al.*[1], who on page 219 of this issue trace the evolution of complex sociality within the order Primates. Their data provide a strong foundation for modelling the origins of hominid mating systems by constraining the range of likely trajectories of social change.

Decades of hard work by hundreds of field researchers have provided a rich body of knowledge about the social organization of non-human primates[2]. Like many mammals, members of a few primate species lead a largely solitary life as adults, meeting only to mate or exchange calls at the borders of their territories (for instance, Coquerel's dwarf lemur, *Mirza coquereli*). By contrast, other primates are found in groups consisting of one adult male and multiple adult females (gorillas), or form large groups consisting of several males and females (baboons), or pair up to form lasting bonds and live in family groups (gibbons and humans).

Shultz *et al.*[1] set out to assess the effects of phylogenetic history on social organization and to examine the pattern of change in such organization across time. For this, they combined information about the social organization of 217 living primate species with information about the genetic relationships among species within the order. They conclude that social organization has a strong phylogenetic component, because it tends to be more similar among closely related species than would be expected by chance.

The authors also evaluate the patterns of change from one form of social organization to another. It seems logical that solitary social systems would give rise to stable bonds between pairs, as temporary rendezvous between males and females for mating are lengthened into enduring associations. It also makes sense

Figure 1 | Living together. Shultz and colleagues' study[1] throws light on developments that led to the stable communities in which chimpanzees exist today.

that there would be a steady progression from small groups to larger, more complex ones. But apparently this is not what actually happened. Instead, Shultz and colleagues' phylogenetic records reveal a set of largely unilateral transitions, some 52 million years ago, from solitary life to loose aggregations of multiple males and females. From there, more stable multi-male, multi-female groupings arose. And from the stable groups, both pair-bonded and one-male harems emerged roughly 16 million years ago.

The existence of a strong phylogenetic signal spells trouble for socioecological models that aim to explain the evolution of primate social organization. The models hypothesize that food distribution shapes competitive regimes, and that these, in turn, shape dispersal patterns and the nature of relationships within groups[3–5]. These models generally assume that phylogeny does not impose notable constraints on social organization, and that changes from one form of social organization to another are all equally likely. But there is a growing realization that history does have a role[6–8], and the new results[1] strengthen that view.

Shultz and co-authors do not explore the selective forces that favoured the transition from one stage of social organization to the next in particular primate lineages. However, they show that the initial shift to sociality coincided with a transition from a nocturnal lifestyle, in which being inconspicuous is an important protective strategy against predators, to a diurnal lifestyle, in which there is safety in numbers.

Their data also provide insight into sex-biased dispersal patterns. Dispersal is a way to prevent inbreeding, and in many primate species, including chimpanzees, members of one sex move away from their natal group, whereas members of the opposite sex stay behind throughout their lives. In these species, sex-biased dispersal patterns allow the formation of cooperative relationships among members of the resident sex[9]. Shultz *et al.* report that sex-biased dispersal patterns arose after the transition to multi-male, multi-female groups — not before. This suggests that the benefits of cooperating with resident kin did not drive the evolution of sociality in primates. Instead, stable residence patterns provide opportunities for forming cooperative relationships with group members, particularly with close kin.

The direction of the transition from stable groups with multiple males and females to pair-bonded groups is of particular interest for at least two reasons. First, it challenges assumptions about the nature of social complexity. In the past few decades, the social-brain hypothesis has held sway in primatology[10,11]. According to this hypothesis, the demands of living in large groups with a host of potential rivals favoured the evolution of greater cognitive abilities: the larger the group, the more complicated the social terrain and the greater the need for cognitive sophistication. But Shultz and colleagues' finding that there has not been a steady progression from small groups to larger ones suggests that social complexity is not a simple function of group size.

Second, these findings provide some insight into events that may have occurred within the human lineage. The last common ancestor of humans and chimpanzees lived about 5 million to 7 million years ago. We know nothing about the social lives of these creatures, but we do know that modern chimpanzees live in stable communities consisting of multiple males and females (Fig. 1). The new results make it unlikely that the last common ancestor was pair-bonded, because this would imply an improbable transition from pair-bonds to larger groupings within the chimpanzee lineage. This also means that the shift to pair bonds must have occurred sometime after the divergence from this ancestor.

Shultz and colleagues' paper[1] is unlikely to attract the kind of fanfare that accompanies the discovery of a new hominid fossil or the sequencing of an ancient genome. But it is likely to play an essential part in modelling the evolution of sociality in primates, in interpreting the fossil record and in reconstructing the lives of our ancestors. ■

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PLANETARY SCIENCE

Ancient lunar dynamo

The differential rotation between the Moon's core and mantle may have powered the ancient lunar dynamo, either continuously over several hundred million years or intermittently after large impacts. SEE LETTERS P.212 & P.215

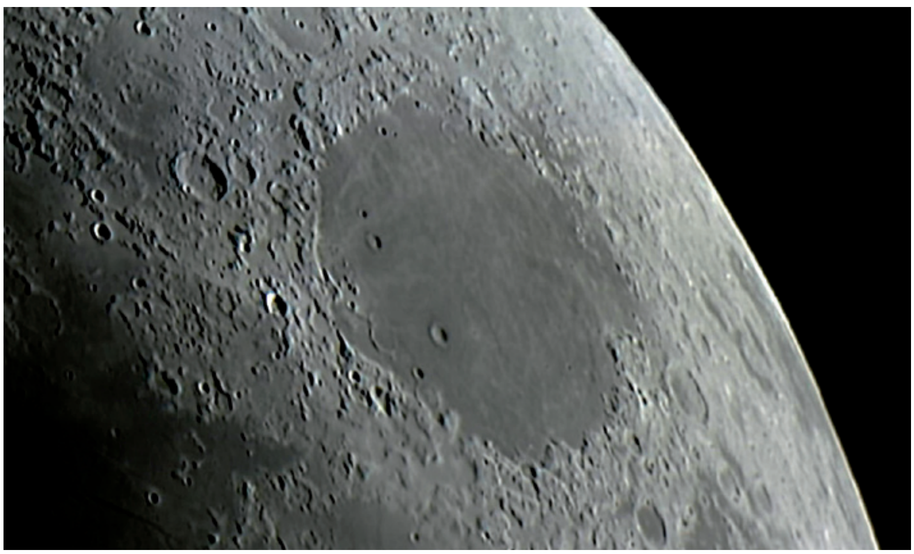
DOMINIQUE JAULT

Possible energy sources have long been sought for a dynamo that could have produced the magnetic field possessed by the Moon 4 billion years ago[1]. In this issue, Dwyer *et al.*[2] and Le Bars *et al.*[3] show how the ancient lunar dynamo, which acted in the Moon's fluid core, may have been mechanically driven.

The two teams describe fluid dynamos that could account for the magnetization of the lunar crust[4,5]. Both groups investigate the fluid motions spawned by the fast spin of the Moon's fluid core past its solid mantle. Dwyer *et al.*[2] (page 212) consider that the misalignment between the rotational axes of the core and the mantle — which has persisted throughout the Moon's history — resulted from the almost perfectly spherical shape of the lunar core. Le Bars *et al.*[3] (page 215) examine the sudden differential rotation between the core and the mantle that followed large impacts on the Moon's surface. Le Bars and colleagues' dynamo works only briefly, but for long enough to magnetize the basins formed after the impacts that ignited the dynamo process.

Dwyer *et al.* build on a finding[6] that predated the Apollo programme: that the small ellipticity of the Moon's core surface means that the lunar core does not follow the mantle in its precession. Inertial coupling, which results from centrifugal pressure acting on Earth's elliptical core–mantle boundary, causes Earth's core and mantle to precess in sync. This mechanism is not viable for slowly rotating bodies such as the Moon as it is today. According to Dwyer *et al.*, it has not been active for most of lunar history, during which the lunar core's rotational axis has remained nearly normal to the ecliptic (the plane of Earth's orbit around the Sun): viewed from the core, the mantle rotates about an equatorial axis, which revolves about the core's rotational axis. Analyses based on lunar laser ranging — which involve measuring round-trip travel times of laser pulses between Earth and the Moon — have confirmed[7] that, at present, the core rotational axis is normal to the ecliptic plane. Le Bars *et al.*[3] investigate an alternative hypothesis, whereby the differential rotation was transient and organized about the Moon's polar axis.

The two studies[2,3] give different reasons to expect differential motion between the liquid core and the solid mantle of the early Moon. From this perspective, it is advantageous to read the two articles side by side. Both exploit



GALAXY PICTURE LIBRARY/ALAMY

Figure 1 | The Crisium lunar basin. Le Bars and colleagues' model[3] for the ancient lunar dynamo explains magnetic anomalies of several impact basins, including Crisium.