

CO<sub>2</sub> and stop the planet from frying up; and they underpin the ecosystems and biodiversity that are central to sustainability. Also, they are excellent model organisms for fundamental processes in biology: *vide* Hooke, who discovered cells in cork in the seventeenth century; Mendel and genetics in peas; van Beijerinck who first described viruses in tobacco; McClintock and mobile genetic elements in maize; and many others. How could I want to work on anything else? Modern botany contributes both to medicine and environmental science.

**What would you be if you were not a biologist?** Probably an economist. I am concerned about the sustainability of current economic models that are dependent on growth and in which the currency is money rather than well-being and quality of life. Even in this other life, however, I might well find myself looking at cells and ecosystems as examples of complex, self-correcting systems that could be used as models for a new economics.

**Economics is still science: what about a life outside science?** I think it was Lewis Wolpert who referred to a truth in the arts and humanities that is unconstrained by reality. I feel very comfortable with another truth that is constrained by reality and so I have found my niche in science. We all use the unconstrained truth either consciously or not when we imagine, for example, and I have great admiration for the people that use this other way of thinking more completely than I do. I enjoy their paintings, music and writing and their presence in my life but I wouldn't want to fly in an airplane, cure disease or grow crops according to their unconstrained truth. Of course, if I did abandon reality completely, I would be a second Charlie Parker.

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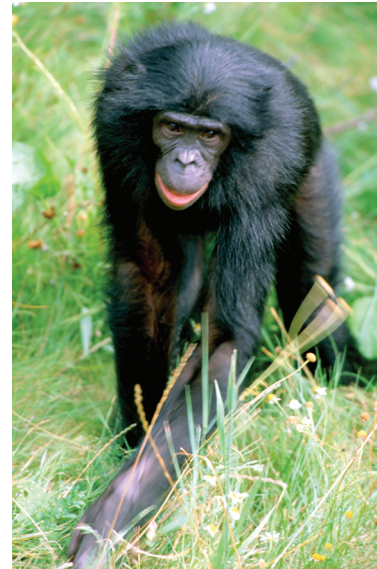
## Quick guide

### Bonobos

Linda Vigilant

**What is a bonobo?** One of the last major mammal species to be formally identified, the bonobo (*Pan paniscus*) is still much less familiar to people than its close relative the chimpanzee (*Pan troglodytes*). Chimpanzees and bonobos look much alike, and the bonobo was formerly termed the 'pygmy chimpanzee', but use of this misleading moniker is now discouraged. Physical differences between the two species include a more slender build and longer head hair for the bonobo, along with a suite of behavioral differences. Even before the formal description of the species in 1929, which was based upon skull morphology, the pioneering primate behavior researcher Robert Yerkes noted the unusually pleasant temperament of a particular 'chimpanzee' — now known to be a bonobo — under his care. Scientists are still trying to understand how chimpanzees and bonobos turned out so differently despite living in apparently similar ecological environments.

**How's their social life?** Like chimpanzees, bonobos in the wild live in groups or 'communities' composed of multiple adult males and females and their offspring. In contrast to chimpanzees, bonobos appear much more egalitarian in their social interactions. Even though they leave their natal communities upon reaching maturity and settle in a new group, the females manage to form strong social bonds and exert social dominance over the males, an exceedingly unusual turn of events for primates. In practical terms this means that females have control over feeding resources, and face little retaliation for aggression directed towards males. Adult males



Ulindi is the dominant female in the bonobo group in the Wolfgang Koehler Primate Research Center at the Leipzig Zoo, where she is choosy about participating in psychology tests. (Photo: Michael Seres.)

retain strong bonds with their mothers, and one study of a wild group suggests that sons of high ranking mothers are particularly successful in the important matter of siring offspring. In keeping with their more peaceful reputation, bonobos have not been observed to engage in the cooperative hunting and consumption of monkeys so often enthusiastically practised by chimpanzees. While bonobo groups occupy specific territories, these can be highly overlapping and even matings across community lines have been reported, while aggressive patrolling of territory boundaries and fearful avoidance of neighbors is more typical for chimpanzees.

The bonobo characteristic that invariably elicits attention is their seeming tendency to have sex all the time. Not only is the frequency of sexual behavior remarkable, but also the manner — pairings can include all imaginable age and sex combinations. This is attributed to the use of sex not just for reproduction, but as a flexible social tool. Engaging in a copulatory bout can mark reconciliation, reduce tension, or elicit social or food benefits.

**Where do they live?** Bonobos are restricted in the wild to equatorial rainforest in just one country, the Democratic Republic of Congo. They occur south of the Congo river, which separates them from populations of chimpanzees. Bonobos and chimpanzees diverged rather recently, perhaps less than a million years ago. Reliable estimates are hard to come by, but probably fewer than 10,000 bonobos survive in the wild, and they face the usual threats of forest-dwelling primates such as hunting, habitat destruction and infectious disease. A few hundred live in captivity and many inferences regarding their social life and behavior are based upon observations of such groups. Although field research on wild bonobos began at two sites more than thirty years ago, civil unrest has repeatedly disrupted the course of observations. Additional sites have been established in the last few years, important because it is necessary to compare the behavior of bonobos living in different ecological and demographic conditions in order to understand the full range of their natural behavior in the wild.

**Bonobo smarts** Bonobos, like chimpanzees, are typical subjects of problem-solving experiments aimed at understanding how ape cognition both differs from and resembles that of humans. Pairs of either chimpanzees and bonobos can be induced to work together towards achieving goals that yield a food pay-off for each partner. But bonobos may continue to cooperate even when the treat will clearly end up monopolized by one of the partners, suggesting that they are more flexible cooperators.

The most famous individual bonobo is Kanzi, who surprised researchers by learning the rudiments of keyboard-assisted communication not through direct instruction, but by watching researchers trying to teach his mother (who never did get the hang of it). He understands several hundred

words in spoken language, a performance roughly comparable to that of a two-year old human. The accomplishments of Kanzi and other language-using apes have attracted much interest as well as controversy, with some researchers suggesting that the emphasis on the accomplishments of the apes overshadows the substantial differences between language use by apes and small children. A more useful comparison is perhaps between language-using and language-naïve apes, for example in a variety of manipulative tasks, in order to ascertain how understanding of symbolic communication can affect performance in other areas.

**The other closest relative of humans** Bonobos are as closely related to humans as are chimpanzees. In fact, aspects of their gracile morphology, their propensity to use an upright gait, and their social organization have inspired some researchers to argue that they can serve as a useful model for what the last common ancestor of *Pan* and humans might have been like. The chimpanzee genome was sequenced by an international consortium and published to great fanfare in September 2005. With the chimpanzee genome available to researchers looking for differences unique to humans or chimpanzees, a bonobo genome sequence might seem redundant. But bonobos and chimpanzees have undergone divergence very recently, and genome-wide comparisons could help show whether this split was characterized by prolonged periods of gene flow, or was a rather sudden event precipitated by the Congo river as a barrier. Another intriguing argument for sequencing the bonobo genome is that comparison of the bonobo and chimpanzee genomes might be an interesting counterpart to the comparison of the genomes of two even more recently diverged taxa: Neandertals and modern humans.

**Bonobo population genetics** Thus far, comparative studies of neutral genetic variation in apes have found that the bonobo has low levels of diversity, similar to that found in humans or the eastern chimpanzee subspecies, several-fold lower than the diversity in other apes. In the case of humans, this almost certainly reflects a history involving a population bottleneck and subsequent recent expansion. Because the ape samples used in such studies come from captive individuals, it is not clear whether sampling effects or population history would best explain the relatively low variation observed so far in bonobos.

A few studies have used samples collected from multiple localities in the wild to try and infer patterns of genetic variation across the range of the bonobo. An approach using the maternally inherited mitochondrial DNA found several different mitochondrial DNA types in local populations, as would be expected in a female-dispersing species. In addition, a subtle effect of rivers as a barrier to gene flow was also observed, with genetic distances correlating with geographic distances only when distances were computed to bypass substantial rivers occurring in the Congo basin. Some researchers have speculated that male-mediated gene flow between groups may occur in bonobos, either through inter-community matings or occasional acceptance of immigrant males. However, a study of Y-chromosome variation in individuals from several localities suggests that any such male dispersal is far exceeded by female-mediated gene flow.

**Where can I find out more?**

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