students increasingly become interchangeable cogs in giant, grant-fuelled research machines that sap their independence and potential. Increasingly, professors routinely put their names on students' papers, gaining gratuitous co-authorships that are not only undeserved but unnecessary. Funding agencies don't care whose name is on the paper, so long as it comes from the investigator's lab. Another invidious trend is the increasing pressure on researchers to get not one grant, but multiple grants to raise overhead money for the university. More and more, one's standing is judged by grant income rather than research quality. This has deeply corrupted biological research in America.

What advice would you give a beginning graduate student? Don't be afraid to look stupid: you'll never learn anything if you're afraid to ask 'dumb' questions. Experiments will often go wrong: behind every successful scientist there is a hidden string of failures, which are inevitable when finding out how something really works. All experiments obey Coyne's Law: the real time necessary to do an experiment is triple the expected time. If you're not in the lab on weekends, it's a bad sign. Hard work is much more important than brains. Finally, don't let anyone put their name on your papers unless they did some of the work (funding doesn't count)!

What kind of research would you encourage in evolutionary biology? Systematics is the backbone of all work in evolution, including speciation, and is an underappreciated field that has made huge contributions to our understanding of nature. Genomics and bioinformatics — the current fads in a faddish field —have also been quite powerful, but at some point we'll need to understand those DNA changes by going back to study the whole organism in its environment.

Department of Ecology and Evolution, The University of Chicago, Chicago, Illinois 60637, USA.
E-mail: j-coyne@uchicago.edu

Quick guide

Gorillas

Linda Vigilant and Brenda J. Bradley

Where the wild gorillas are. Gorillas live only in the forests of equatorial Africa. Their distribution is strikingly discontinuous, with the majority of wild gorillas found in west-central Africa in Gabon, Republic of Congo, and neighboring countries, while much smaller populations exist about 1000 km away in eastern Democratic Republic of Congo, Uganda and Rwanda. Good estimates are hard to come by, but the gorillas in the east total perhaps in the tens of thousands, including the mountain gorilla, which has experienced a slight rebound in the past few years and now numbers about 650 individuals in two separate populations. Recent reports suggest that the Ebola virus is one likely cause of the recent disappearance of at least half of the 90,000 gorillas estimated formerly to live in west-central Africa. In addition to disease, gorillas are highly threatened by the commercial bushmeat trade and so enforcement of anti-poaching laws is a top priority for gorilla conservation efforts.

You can call me gorilla. But it is worth noting that two species of gorillas have recently been officially recognized. The mountain and lowland gorillas of East Africa are dubbed *Gorilla beringei*, while the western gorillas have the simpler moniker *Gorilla gorilla*. The classification as two separate gorilla species rests principally upon reinterpretation of differences in cranial measures and general morphology. Some estimates of molecular divergence times based upon mitochondrial DNA data are similar for the two gorillas and for chimpanzees and bonobos, on the order of one to two million years ago, hinting that concurrent biogeographic events may have influenced the evolution of these apes.

Compared to African apes, by nearly all measures humans have reduced genetic diversity, which has been attributed to a population history featuring a severe bottleneck and subsequent expansion. The demographic histories of the chimpanzees and western gorillas appear to have been more stable, but it is still a bit of a puzzle as to which one contains higher average levels of genetic diversity. Analyses of mitochondrial DNA suggest that chimpanzees and gorillas are three and two times as variable as humans, respectively, but a recent analysis considering variation at a large number of nuclear loci puts gorillas in the lead. Such comparisons are complicated by population structure, and an excess of intermediate-frequency single nucleotide polymorphisms in gorillas suggests a history of population subdivision. Investigation of that possibility, and a generally better view of the effects of social structure and past changes in population size on genetic diversity, demands analysis of samples from known localities in the wild. This is easier said than done, but recent results suggest that it may be possible to generate nuclear sequences up to 1 kilobase in length using DNA extracted from feces.

Who's the odd ape out? The visible similarities between gorillas and chimpanzees — for example, knuckle walking, abundant body hair and thin tooth enamel — gave a long-standing, yet misleading, impression that these apes were sister taxa, and that humans were the exceptional outgroup in this hominoid trio. It is now clear, however, that humans and chimpanzees are the most similar of the three for the majority of their genomes, but for some parts of the genome, it is either humans and gorillas, or gorillas and chimps that are the closest relatives.

This implies that the events in the late Miocene that led to the evolution of gorillas, chimpanzees, and humans from a single common ancestor occurred

over a rather short period of time. In practical terms, this means that comparison with data from gorillas may be useful for evaluating and understanding the significance of the genetic differences being identified between humans and chimpanzees. For example, analyses of the human and chimpanzee genomes indicate that some of the genes showing the strongest signs of positive selection are ones coding for proteins involved in reproduction. But humans have throughout their history shared with gorillas a tendency to live in families containing a single male and multiple females, rather than the multi-male, multi-female groups observed for chimpanzees. This suggests that some genes that vary between humans and chimpanzees may not reflect uniquely human changes, but rather the high levels of sperm competition among chimpanzees.

Hairy harems. Gorillas show extreme size dimorphism, with males weighing almost twice as much as females. This attribute almost certainly results from their harem social structure in which only a few big guys get all of the girls. Gorilla social life usually centers around one fully mature silverback male — in eastern gorillas, groups can have two or more silverbacks, but even then there is only one alpha male — and females seem to prefer the males who offer the best protection. Male protection is important to gorilla females; without it their dependent offspring are likely to fall victim to infanticide by other males.

Big bodies, small genitalia. Although sexual selection seems to have favored large-bodied males, even the most intimidating silverback gorillas have rather minute genitalia, about one-third the size of those possessed by the average human male. As gorilla females are unlikely to copulate successively with numerous silverbacks, direct male–male competition for females likely plays a much larger role in gorilla male reproductive success than does sperm competition. This is in stark contrast to chimpanzees, for which copulation rates during opportunistic mating are about once per hour and males are correspondingly well-equipped for sperm production.

Gorilla ears look uncannily like those of humans. Photo by M. Seres, MPI-EVA.

Is there a gorilla equivalent of Lucy? Not yet. The evolutionary history of gorillas — and chimpanzees too, for that matter — is a gaping hole in our knowledge of primate evolution. The human fossil record, although sketchy, is bountiful compared to the virtually non-existent record of the African apes. Unfortunately, the acidic soils of the forests in which these ape ancestors lived was probably unfavorable to bone preservation.

Tools: who needs 'em? In contrast to the situation with wild chimpanzees, tool use has not yet been described from any wild gorilla research site, despite years of cumulative observation. Two explanations for this apparent lack that immediately come to mind are that gorillas simply do not need tools and so do not bother, or are just too dim. Tool use in wild chimpanzees commonly occurs in conjunction with the acquisition of otherwise hard-to-acquire foodstuffs, such as underground termites or kernels of hard-shelled nuts. Gorillas, on the other hand, graze through a landscape of leafy plants, terrestrial herbs and sometimes, depending upon the area, fruits.

Interestingly, while tools do not seem to be required, intricate skills in food manipulation are sometimes needed to cope with bristly thorns and spines, and those food-prepping maneuvers have been suggested to require cognitive skills similar to those underlying tool use. Further evidence that gorillas could use tools if they only needed to comes from experiments with captive apes, which found that orangutans — which use tools in the wild — and gorillas displayed a similar ability to choose a stick of appropriate length to get at an out-of-reach treat. In general, controlled experiments investigating the cognitive abilities of gorillas are much less frequent than studies of the more commonly available chimpanzee. But new research is moving beyond documenting differences just between humans and chimpanzees in matters such as tool use, intentional communication and social cognition, and taking a broader perspective in examining the range of differences across great apes, including gorillas.

Where can I find out more?

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Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, D-04103 Leipzig, Germany.
E-mail: vigilant@eva.mpg.de, bradley@eva.mpg.de