GREGORY BENFORD

IS IT SMART TO BE SMART?

IS IT SMART to be smart?

Of the billion species that have thrived on Earth since the first cells, we are the only one to achieve high intelligence. Medium-higher levels appear only in other primates, some carnivores, and whales. It would appear that getting smarter has not been a wise career move for most animals.

Evolution rewards getting one's genes into the next generation. All life is in a furious competition to make copies of itself -- actually, half-copies, for sexual reproduction (which is not just fun, but the preferred mode among all animals) carries forward only half the genes of each parent.

One need not be a cliche intellectual wallflower at the high school dance to suspect that intellect is far down on the list for selection.

This has implications for the Search for Extraterrestrial Intelligence, SETI. Big brains are not so much an advantage that they have been invented repeatedly. This is how evolutionists usually evaluate a property: by asking whether it developed often.

Generally, the number of times an ability appears is driven by both how easy it is to get, and how useful it is. Eyes (or at least well-developed light-sensing equipment t appeared independently at least forty times in widely varying organisms. Similarly for hearing, binocular vision, and other useful tricks.

Of course, high intelligence has a high down payment. The only way we know to develop intelligence lies in having big-brained children, who can learn varied responses to their world. This proves, in us, a better route than embedding in our genes elaborate programs which tell us how to hunt, forage, mate, etc.

But big-brained children then require lots of care-giving time from their parents. Somebody must feed them while they learn artful ways of feeding themselves.

So slight increases in intelligence had better pay off from the first, giving a species a decided advantage in the genetic sweepstakes. Running big brains also eats up calories, as we'll see later.

Homo sapiens has been around roughly 300,000 years, only six percent of the time that hominids have tramped across Africa. (A hominid is any primate between ourselves and the chimps; all the others are now extinct.) We have been clever enough to build radios for only one century. Can we readily expect to hear radio signals from similarly smart species elsewhere? How common can we expect intelligence to be in the galaxy?

There are many ways to approach the intriguing questions which emerge from such ideas. Why did tree-dwelling shrews of 65 million years ago, minor bit players in the jungle drama, evolve into us big-brained lords of creation?

One method is to ask how rather than why -- why not in the "who caused this?" sense, but in the "what over-arching principle made this happen?" sense. Plainly natural selection is at work, but what mechanism does it use, in this case?

Asking the question this way is less vulnerable to the charge that we are simply telling "Just-So stories" to make the mysteries of vast time scales seem understandable. Big brains are useful for processing external stimuli and for formulating models about those data, and even for telling one's fellows about these ideas.

But how does an organism get the big brain to do these marvelous things? Would extraterrestrials follow the same path?

Suppose we approach brains as an engineering problem. A new-born's brain burns about 60 percent of its intake energy, a huge investment in a gray nugget that doubles in size in the first year. Rather than focus on the advantages of big brains, their huge energy consumption argues that evolution always had to consider tradeoffs. Our brains three million years ago were about the size of a modern-day chimpanzee's, and have tripled since, while our bodies are not even twice as large. Some clever energy savings had to happen for this to occur.

Firing neurons and manufacturing neurotransmitters, brains demand bigger hearts and lungs to carry the oxygen and nutrients for this work. There are brains four to six times larger than ours in elephants and the baleen whales, but at a price of far larger bodies to support them. How are we more efficient? Apparently, by trading guts for brains--an interesting metaphor.

The most obvious savings lie in our rather small digestive tract, which is about 60 percent smaller than in a similar-sized primate, just about balancing our increased brain. It takes a massive gut to digest raw plants and nuts. Eating meat requires a simpler, smaller digestive tract investment.

Higher quality digestion does not drive brain size, of course. Pigs have rather smaller stomachs, proportional to their weight, but evolution did not favor smarter pigs (though as mammals go they are not dumb); the investment went elsewhere.

The same holds for birds and bats, who have the demands of flight to limit their brain sizes. All this suggests that something special about primates was at work on us and the chimps, who lie somewhere between us and the other primates in brain/gut mass ratios.

There are suggestive refinements to this basic engineering view. The big crunch in brain energy need comes in the first few years of life, precisely when our maternal care is also so vital. Mothers provide the extra energy babies need through milk, and infants invest it in their brains. This pattern of large parental investment we have extended into longer and longer periods of dependency.

At a price. The birth canal diameter sets a severe limit on head size at about ten centimeters. We are born very immature, with flexible skulls. Some babies cannot even breathe on their own.

Some feel that these traits evolved around two million years ago, with a switch to a diet high in protein and fat, aided by tool use, cooking, and eating lots of meat. This is a positive feedback loop, driving the cognitive side of brain functions through the engineering constraint of energy for a given body mass. We found a social term in the feedback which made mothering essential over longer times.

Of course, there were other changes. Attaining an upright posture made it easier to balance that heavy brain on a spine, rather than hanging it at the end, levered against gravity by strong neck muscles, as four-footed beasts do. But these engineering demands probably did not drive our erect posture at first; more likely, hands did.

Freeing our forepaws made their development into hands for gripping, throwing, and tool-making far easier. Some evolutionists believe that as the African plains dried out, stands of trees became farther apart. Standing upright is a faster way to cross the dangerous stretches of open country, chimps do this today, holding their arms over their heads for balance. Standing to run is safer, too, because then they can see over tall grass.

The price was that babies had to be held, because we were losing our pelts and they could not hang on, as they had done in the trees. (Actually, we may have the same number of hairs as our ancestors, but ours are far finer, and let air flow to cool us. We keep some hair over most of our bodies, apparently to alert us to insects prowling on US.)

Thirty million years ago the African forest lay unbroken and many large primates lived in it. Today forests are spotty and only four large species remain -- us, chimps, gorillas, and orangutans. This suggests how profoundly external changes shaped us.

Neurophysiologist William Calvin believes that learning to use our hands orchestrated our growing brains into more and more complex movements --jabbing with spears, say, and then throwing sharp rocks. (See his The Ascent of Mind.) No other animal has such suites of abilities, and Calvin suggests that this drove our ability to string guttural noises together so that they could carry meaning: speech.

Continuity of effort lies deep within us. We love the sense of flow in physical movement enough to enjoy sports, seeing in it a drama and significance far beyond the objective importance of, say, moving a pigskin around a field. We say "He loves the sound of his own voice" as a mild rebuke, ruefully admitting that we share a love of extended expression, as well. (The pleasure process does not have to be strictly verbal, either, or else no one would write books, or columns like this one.)

There are signs of similar love for extended action in the animal kingdom, as when a hawk soars to great heights, sometimes riding thermals a mile high in the sky, without any apparent hunting motive.

Perhaps this ability to "throw long" mentally is deeply implicated in our evolutionary preference for bigger brains. Calvin and others have argued that the periodic ice ages, driving populations to and fro across latitudes over the last 2.5 million years, vitally forced selection for a brain-tool connection. Climate varying on all scales between decades and many millennia surely would be a persistent fitness filter.

There is another clue in nature to the big-brain issue. Cetaceans--whales, porpoises, and dolphins--also have large brain/body mass ratios. What can we learn from them? As biologist Lori Marino observed, "Fifty-five million years ago, a furry, hoofed mammal about the size of a dog ventured into the shallow brackish remnant of the Tethys Sea and set its descendants on a path that would lead to their complete abandonment of the land." They are a prize example of mammalian adaptability, for though we have quite recently spread over all the Earth, into every clime, they ranged through the oceans many tens of millions of years ago.

Of course, aquatic animals have slight appendages, and labor under different engineering constraints. Still, the "encephalization quotient" (this is basically a ratio of the cerebral cortex volume to that of the underlying brain -- the higher the ratio, the smarter the creature. Let's call it EQ) of the cetaceans lies between ours and the other primates. There are several different ways of calculating EQs, and one useful method assigns us a value of 2.88, with common chimps at 0.97. Between those lie the dolphins and porpoises, with values ranging from 1.89 to 1.58. These exceed the first hominids; we apparently overtook the cetaceans in EQ around two million years ago.

Perhaps the most important fact from fossil dolphin work is that the cetaceans attained their high levels about fifteen million years ago! By this measure, they have been fairly smart for a long time. Big brains are not, then, a trait that keeps driving to our high limit.

Together with our spurt of brain growth, trebling in two million years, it seems that the factors driving us upward in brain size (and presumably toward better brain organization as well) are unlike those which made the cetaceans bright. As well, our brains are organized quite differently, and parallels are hard to find. This means the cetaceans are a valuable, different case of evolution upward in general intelligence.

There is much disagreement about just how smart the cetaceans are, with factions differing over how to measure intelligence at all. But some sophisticated social organization seems clearly implied by their reliance upon complex song and ability to solve a wide range of problems, many requiring chains of inference strikingly long.

There are other features in our development that reveal deep similarities. Evolution of big-brained cetaceans seems to have occurred when the southern oceans cooled and there was considerable biotic turnover. This parallels our conventional wisdom that hard times in African climes drove hominid evolution. Did porpoise brains level off in size once the oceans calmed down? Research is not detailed enough to say, as yet.

Environment may have been a major player in dolphin evolution, but so was social evolution. The cetaceans' basic social grouping is the "pod," ranging in size from a few to around forty. Interestingly, pod size scales up roughly with EQ. This resembles the primates, for whom mean group size also rises with EQ, from one to a hundred individuals. If group size measures social complexity, as seems plausible, this suggests a commonality between us and the cetaceans. They form a telling boundary case by which we may mark our uniqueness in nature.

No other placental mammal has as great a ratio of brain size to body size as we do, and we might be very near the design limit. Much larger and our heads would seriously endanger both mother and child while passing through the birth canal. It is a happy accident that this limit is enough to give us the room to cogitate on matters such as our own origins. If the limit had been, say, at a brain size half our current average, we might be still the lords of creation, but we would not reflect upon that fact.

Of course, we are not just great thinkers; we are great, incessant talkers as well. Some evolutionary biologists think we may in part have grown big brains to gossip, stitching up our social fabric.

Evolution is a miserly opportunist. About ten million years ago it worked upon the primate ancestors we share with the chimpanzees, making small adjustments in existing parts to create advantageous change. We have much in common with the chimps.

We use the standard-issue mammalian hearing structures, which can resolve ten sounds per second but no more, apparently because there were not a lot of clues faster than that in our world. Larynx, throat and mouth were engineered to process food, perhaps then retrofitted to process grunts, then words. Our upper mouths and nasal passages can give us sinus headaches, but they also lend our voices a deep, resonant quality, like notes heard from the ceiling sound chamber of a concert hall. Such tones are rare in nature and presumably proved useful.

Some evolutionists believe that early brain circuitry worked out to control hand movements got coopted into speech-making. How neurons built up to move fingers got retooled into circuits able to pull words from a dictionary and insert them into a flowing syntax is a tantalizing mystery.

Plainly the ten million years since we parted genetic company with the chimps have shaped us for speech, pointing to profound evolutionary pressures. Since the seventeenth century we have tried and failed to teach chimps to talk. They can artfully use sign language with vocabularies of around 500 words, so the neural circuitry is in place. Perhaps they used more sign language in the past than they do now, for their present capacity seems underemployed in the wild.

Our complicated way of making speech is a Rube Goldberg kludge. Like most animals, apes can swallow while they breathe. We cannot, because our oblique upper vocal boxes block our upper windpipe. Our shorter jaws squeeze our wisdom teeth, making them prone to impacting and rot. The thinner jaw bone supports smaller teeth, making chewing harder. All these disadvantages, which could prove fatal in adversity, were worth the gain of speech.

Still, chimps seem as though they should be able to get out some smothered phrases like our speech, if only their brains were geared that way. But they aren't, a clear sign of how our brain "hardware" and "software" differ.

No animal but us can rap out quick strings of varied, precise noises, syntactically arranged. There are monkeys who can hold fruit in their mouths, peeling and swallowing and spitting out pits at machine-gun speed. Competition for scarce food and poisonous pits explain why evolution would prize such selection. Our mouths have simply followed another path, one intricately wired in with our minds.

This is part of a larger problem we have in thinking about our link to animals. We innately sense our connection to nature, especially to those mammals close to us: cats and dogs, horses and birds, our collaborators. We recognize intelligence in the stalking of a good hunting dog.

But talking? We chattering primates set great stock in this recently developed ability, of which Neanderthal may have had only a smattering. Yet some mental template for internal symbol-arranging apparently goes back to that ten-million-year juncture. Recent decades have convinced chimpanzee researchers that these nearest relatives have considerable communication skills, managing sign "languages" of many hundreds of words.

Ample signs of this lie in the long saga of chimp communication. All primates use sound to signal, conveying alarm, status, comfort and delight; chimps even laugh with an infectious mirth that envelops the entire group. Even accents or dialects may modulate their speech.

How tempting, then, to see what else we have in common, particularly socially. Can we understand ourselves better by using the chimps as a mirror?

Just as humans differ among themselves, chimps do -- and rather more profoundly.

The common chimp's short legs, long arms and vastly more muscular body we readily recognize. Few know that the species has split, yielding the "pygmy" chimp, the bonobo. (A beautiful introduction to them is Bonobo: The Forgotten Ape by Frans de Waal, with photographs by Frans Lanting.)

Science missed these intriguing creatures, buried in central Africa's secluded forests, until a discovery of a skull in 1927, and live groups a few years later.

Bonobos aren't actually pygmies; they weigh only slightly less than the familiar chimp, and stand up more than they do. This gives them a strikingly more human look, along with their slender legs and arms and smaller head. Lounging and moving about, they look uncannily like one of us, pleasantly at ease on holiday. Bonobo faces are darker, flatter, with bright red lips and no protruding muzzles.

The central question of how distinctively we differ from the chimps depends on which chimps we mean. Humans, common chimps and bonobos have all evolved away from our remote common ancestor, each pursuing different strategies.

Consider the similarities: we share social patterns like tribalism, and spend our days alternately forming and splitting up groups to accomplish varying tasks ("fissionfusion grouping"). Our females usually (though not always) join the family of the man when they mate; chimps have groups dominated by "alpha males." Infants are dependent for years, far longer than other species, staying close to mothers who give birth at intervals of years. Many social patterns like grooming and cooperative gathering are remarkably alike. Chimps use simple tools, most notably sticks to draw termites from their mounds.

But the bonobos are egalitarian and peaceful, compared with the common, hierarchical chimps. Alpha males lord it over females in common chimpdom, fighting each other for sexual privileges. Bonobos stick together more, spending more time at common tasks or just lounging.

Hierarchy is the essential glue of the common chimp; sex does the job for bonobos. While we humans have the largest genitalia of the primates, the bonobos get more action; they are the sexiest primate, by far. Much of their day passes in a sexual euphoria, with mutual masturbation and oral sex common among all members of the group.

Sex is the safety valve of bonobo society. Fights get settled finally not by grooming but by sex. Visitors use copulation as a calling card. They employ all possible positions, and unlike the common chimp, often have face-to-face sex. Some primate scientists feel this shows an emotional connection seen elsewhere only in humans.

Animal comparisons have for decades now been undercutting our arrogant assertions of human uniqueness. We employ and enjoy a particular primate strategy, no more. Our 98 percent of genes shared with both bonobo and common chimps undoubtedly carries some programming for shared worldviews, desires and social certainties.

Chimps display advanced "cultural" traits. Some groups crack nuts, while others with the means at hand don't. Their social ladders are as precise and well-tended as White House protocol. These imply a sense of self which bears up under clinical experiment. Chimps and other primates know who they are and their place. Plainly they think about matters we would recognize as substantial. Indeed, a few million years ago, we probably played quite similar conceptual games.

We humans seem to stand somewhere between the common chimps and the bonobos. We like hierarchies, from armies to presidents to movie stars, and sometimes will even die for them. The common chimp wages war and commits murder, apparently to expand territory, just like us, though perhaps not as frequently.

We humans use sexual cement, as do the bonobos. We pair off for long times, unlike the common chimp. But sex isn't our dominant organizing principle and major recreation, despite what advertisements might suggest.

Clearly we have evolved social strategies like both types of chimp, with nuances and powers they do not share. How much does this tell us about ourselves?

Some primate researchers have begun to suspect that animal conduct codes come from strategies designed to make social living efficient, and not from some innate sense of evil.

This vision of morality as natural, derived as a design to shore up the passing on of genes, is a big conceptual leap. Such ideas disturb many of us, especially those prone to elevating humans on a pedestal of lofty principles. That is why a long-term chimp observer in William Boyd's novel Brazzaville Beach gets angry just seeing common chimps grow violent in Tanzania's Gombe National Park. Though supposedly a careful scientist, trained to think rationally, he expects better of chimps than of us, and instantly responds to a woman primate specialist's news with ironically chimp-hierarchical rage. He wants chimps to be different, better.

Many others do, too, when looking at primates. Feminists might well embrace the bonobos, who give females far more power, promoting social cohesion. Whether any of us would want humans to become sexual omnivores is another matter. Most of us seem to want our species to lose some of our blemishes, especially aggression.

Generally among animals internal competition is mediated by social rules -- crucially so among the primates, who have both intense societies and great intelligence. Rules get enforced among all primates by tit-for-tat game strategy, with cheaters penalized severely by ostracism.

Sociobiologists have grounded their theories of kinship selection to explain why animals will sacrifice themselves to better the common lot, since they share genes that then get passed on.

High levels of cooperation in turn imply that primate societies coordinate their actions because they can predict outcomes, sometimes remarkably distant in time. Gathering strategies among baboons show memory over days. This is not unique to primates, of course; canines hunt in groups and share the kill, and insects are geniuses of unthinking cooperation.

But primate social systems are more advanced and nuanced than others'. This suggests a long evolutionary history of what we can only term morality. Such development might well apply to any social beings, even aliens or machine societies.

This idea strikes solidly against much prevailing moral philosophy, which tends toward top-down principles that dictate behavior, following logically. Our current model invokes images like Moses bringing down ten commandments. We speak of moral law, not moral efficiency.

Behavioral studies among primates reveal a bottom-up origin for morals and ethics. Getting along and working in concert would shore up the survival of groups which adopted such shared rules. Chimps, and probably our distant hominid ancestors, lived in tribes of one or two hundred souls. Tribes that enforced social rules probably fared better in the competition for food and territory. They did not waste energy and time on internal friction. Building a bias toward such rules into the genome would cement this social invention.

This is not group selection in the old genetic sense, for still it is up to individuals to pass on genes. But it does place all social evolution in a continuum, with us as merely the latest outstanding example.

This larger biological context for ourselves does not mean that humans are merely animals, but that animals are rather more than we have thought. Many will find even this adjustment hard to take.

If right and wrong emerge from social evolution to promote survival, then they are merely utilitarian. Worse, our current ideas of right and wrong have no particular cachet, for they are simply the latest fine-tuned ideas with which we navigate on the strange seas of our quite recent civilization.

Many people, and probably particularly humanists of the "social constructionist" persuasion, will dislike this entire line of reasoning. Its foundation in solid anthropological field work will not matter; it implies a definition of being human that seemingly mocks our dignity, our Renaissance centrality.

Let us take the logic a step further. Unease at such descriptions may itself have a natural origin. In the last six million years we have been accelerated by evolutionary forces we can still only vaguely sense. Wandering the plains of Africa, we may have developed a need to see ourselves as quite distinct from all other life -- higher, better.

This could make our use of other species untroubling. Far easier to slaughter large numbers of game animals by driving them off cliffs or into pits, as our ancestors did, if we can detach ourselves from their death throes. Our sense of our specialness itself might have been selected for at the social level among hominid tribes far in the past.

This ability of evolutionary ideas to trump even the moral misgivings of the humanists is bound to cause even more discomfort. It is a final recta-argument for our profound non-specialness.

Though we are special: the last surviving hominids. We have occupied the smart niche with no rivals since the Neanderthals vanished 35,000 years ago. Until then, there was always at least one competitor primate of intelligence roughly within our range.

We might also expect smart aliens to be alone. Perhaps the shadow across these last 35,000 years has been a vague sense of existential loneliness, with no one to talk to, even with sign language. SETI and our experiments with dolphin and chimp communication may show this shadowy sense.

As for SETI, perhaps crafty intelligence such as ours truly is rare. After all, we seem much smarter than our environment demands. Maybe we are smart mostly because we are so social -- interactively so, not as a mere herd.

Aliens might be equally social, then, which is good news for SETI --they'll want to talk. They might well have a deep moral sense, too, for the reasons I've sketched. That may make it easier to communicate truly difficult, cultural matters.

But their morality would be good for them, not necessarily us. Chimps make war on rival bands, just as we do. Aliens might have a history of war and a visceral dislike of outsiders, just like us. In their science fiction movies, loathsome hairless primates descend from fierce ships, slicing the peace-loving arachnids with their death rays....

Aliens who truly despise and fear other species might have overrun and destroyed their biosphere (as we seem in some danger of doing). We won't hear from them in the radio frequencies, luckily, for they will probably be impoverished.

SETI might detect smart aliens who cooperate with each other readily (avoiding insect-hive sociology, though, which seems unlikely to produce high intelligence). If they have less fear of others, and want to gossip, they might well put out the radio welcome mat -- a bright beacon.

This suggests that we look for the spectacularly successful aliens who might broadcast strong beacon signals--the rich guys. Just as we have come to dominate our planet in an evolutionary instant, something similar may happen on the scale of whole solar systems, elsewhere. Only such a civilization could master the enormous resources to build big beacons.

If so, a strategy of looking toward our galactic center may be best. Not only is the center the one obvious symmetric point in the galaxy, it also lies in the richest, highest density of stars.

Stellar evolution began there and moved outward, stars forming first at the dense central bulge. Our comfortable, suburban region, 2/3 of the way out into the disk, produced the metal-rich planets hospitable to life later than did the stars nearer the core.

Instead of searching nearby stars, maybe we should look more deeply, and inward. It is 9.8,000 light years to the galactic center. There evolution has had nearly ten billion years to work. It might need that much time, to arrive at many such smart rarities as ourselves.

Comments and objections to this column are welcome. Please send them to Gregory Benford, Physics Department, Univ. Calif., Irvine, CA 92717, or benford@uci.edu.