25 | Were Dinosaurs Dumb?

WHEN MUHAMMAD ALI flunked his army intelligence test, he quipped (with a wit that belied his performance on the exam): "I only said I was the greatest; I never said I was the smartest." In our metaphors and fairy tales, size and power are almost always balanced by a want of intelligence. Cunning is the refuge of the little guy. Think of Br'er Rabbit and Br'er Bear; David smiting Goliath with a slingshot; Jack chopping down the beanstalk. Slow wit is the tragic flaw of a giant.

The discovery of dinosaurs in the nineteenth century provided, or so it appeared, a quintessential case for the negative correlation of size and smarts. With their pea brains and giant bodies, dinosaurs became a symbol of lumbering stupidity. Their extinction seemed only to confirm their flawed design.

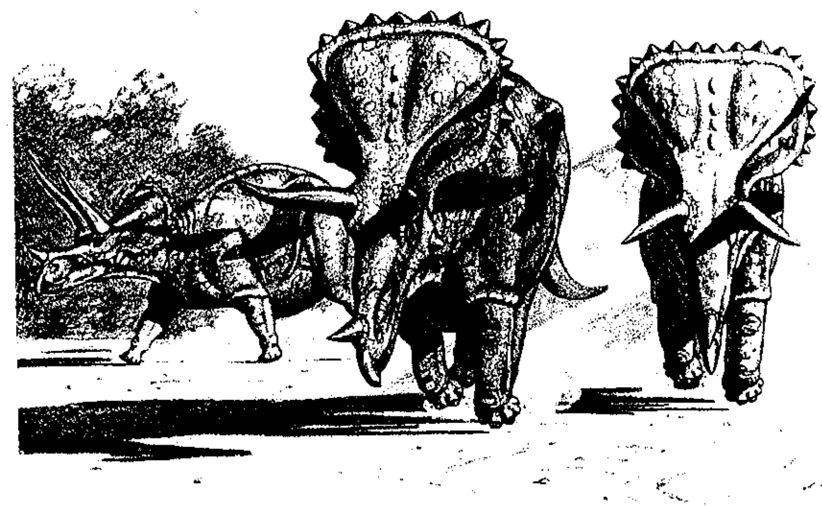
Dinosaurs were not even granted the usual solace of a giant—great physical prowess. God maintained a discreet silence about the brains of behemoth, but he certainly marveled at its strength: "Lo, now, his strength is in his loins, and his force is in the navel of his belly. He moveth his tail like a cedar. . . . His bones are as strong pieces of brass; his bones are like bars of iron [Job 40:16–18]." Dinosaurs, on the other hand, have usually been reconstructed as slow and clumsy. In the standard illustration, *Brontosaurus* wades in a murky pond because he cannot hold up his own weight on land.

Popularizations for grade school curricula provide a good illustration of prevailing orthodoxy. I still have my third grade copy (1948 edition) of Bertha Morris Parker's *Animals of Yesterday,* stolen, I am forced to suppose, from P.S. 26, Queens (sorry Mrs. McInerney). In it, boy (teleported back to the Jurassic) meets brontosaur:

> It is huge, and you can tell from the size of its head that it must be stupid. . . . This giant animal moves about very slowly as it eats. No wonder it moves slowly! Its huge feet are very heavy, and its great tail is not easy to pull around. You are not surprised that the thunder lizard likes to stay in the water so that the water will help it hold up its huge body. . . . Giant dinosaurs were once the lords of the earth. Why did they disappear? You can probably guess part of the answer—their bodies were too large for their brains. If their bodies had been smaller, and their brains larger, they might have lived on.

Dinosaurs have been making a strong comeback of late, in this age of "I'm OK, you're OK." Most paleontologists are now willing to view them as energetic, active, and capable animals. The *Brontosaurus* that wallowed in its pond a generation ago is now running on land, while pairs of males have been seen twining their necks about each other in elaborate sexual combat for access to females (much like the neck wrestling of giraffes). Modern anatomical reconstructions indicate strength and agility, and many paleontologists now believe that dinosaurs were warmblooded (see essay 26).

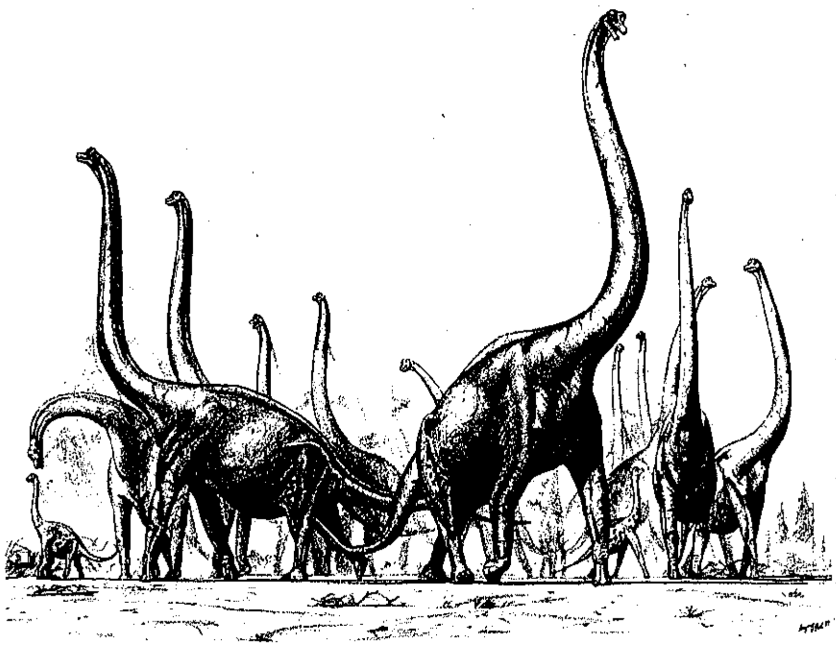
The idea of warmblooded dinosaurs has captured the public imagination and received a torrent of press coverage. Yet another vindication of dinosaurian capability has received very little attention, although I regard it as equally significant. I refer to the issue of stupidity and its correlation with size. The revisionist interpretation, which I support in this column, does not enshrine dinosaurs as paragons of intellect, but it does maintain that they were not



Triceratops GREGORY S. PAUL

small brained after all. They had the "right-sized" brains for reptiles of their body size.

I don't wish to deny that the flattened, minuscule head of largebodied *Stegosaurus* houses little brain from our subjective, top-heavy perspective, but I do wish to assert that we should not expect more of the beast. First of all, large animals have relatively smaller brains than related, small animals. The correlation of brain size with body size among kindred animals (all reptiles, all mammals, for example) is remarkably regular. As we move from small to large animals, from mice to elephants or small lizards to Komodo dragons, brain size increases, but not so fast as body size. In other words, bodies grow faster than brains, and large animals have low ratios of brain weight to body weight. In fact, brains grow only about two-thirds as fast as bodies. Since we have no reason to believe that large animals are consistently stupider than their smaller relatives, we must conclude that large animals require relatively less brain to do as well as smaller animals. If we do not recognize this relationship, we are likely to underestimate the mental



Brachiosaurus GREGORY S. PAUL

power of very large animals, dinosaurs in particular.

Second, the relationship between brain and body size is not identical in all groups of vertebrates. All share the same rate of relative decrease in brain size, but small mammals have much larger brains than small reptiles of the same body weight. This discrepancy is maintained at all larger body weights, since brain size increases at the same rate in both groups—two-thirds as fast as body size.

Put these two facts together—all large animals have relatively small brains, and reptiles have much smaller brains than mammals at any common body weight—and what should we expect from a normal, large reptile? The answer, of course, is a brain of very modest size. No living reptile even approaches a middle-sized dinosaur in bulk, so we have no modern standard to serve as a model for dinosaurs.

Fortunately, our imperfect fossil record has, for once, not

severely disappointed us in providing data about fossil brains. Superbly preserved skulls have been found for many species of dinosaurs, and cranial capacities can be measured. (Since brains do not fill craniums in reptiles, some creative, although not unreasonable, manipulation must be applied to estimate brain size from the hole within a skull.) With these data, we have a clear test for the conventional hypothesis of dinosaurian stupidity. We should agree, at the outset, that a reptilian standard is the only proper one—it is surely irrelevant that dinosaurs had smaller brains than people or whales. We have abundant data on the relationship of brain and body size in modern reptiles. Since we know that brains increase two-thirds as fast as bodies as we move from small to large living species, we can extrapolate this rate to dinosaurian sizes and ask whether dinosaur brains match what we would expect of living reptiles if they grew so large.

Harry Jerison studied the brain sizes of ten dinosaurs and found that they fell right on the extrapolated reptilian curve. Dinosaurs did not have small brains; they maintained just the right-sized brains for reptiles of their dimensions. So much for Ms. Parker's explanation of their demise.

Jerison made no attempt to distinguish among various kinds of dinosaurs; ten species distributed over six major groups scarcely provide a proper basis for comparison. Recently, James A. Hopson of the University of Chicago gathered more data and made a remarkable and satisfying discovery.

Hopson needed a common scale for all dinosaurs. He therefore compared each dinosaur brain with the average reptilian brain we would expect at its body weight. If the dinosaur falls on the standard reptilian curve, its brain receives a value of 1.0 (called an encephalization quotient, or EQ—the ratio of actual brain to expected brain for a standard reptile of the same body weight). Dinosaurs lying above the curve (more brain than expected in a standard reptile of the same body weight) receive values in excess of 1.0, while those below the curve measure less than 1.0.

Hopson found that the major groups of dinosaurs can be ranked by increasing values of average EQ. This ranking corresponds perfectly with inferred speed, agility and behavioral complexity in feeding (or avoiding the prospect of becoming a meal). The giant sauropods, *Brontosaurus* and its allies, have the lowest EQ's—0.20 to 0.35. They must have moved fairly slowly and without great maneuverability. They probably escaped predation by virtue of their bulk alone, much as elephants do today. The armored ankylosaurs and stegosaurs come next with EQ's of 0.52 to 0.56. These animals, with their heavy armor, probably relied largely upon passive defense, but the clubbed tail of ankylosaurs and the spiked tail of stegosaurs imply some active fighting and increased behavioral complexity.

The ceratopsians rank next at about 0.7 to 0.9. Hopson remarks: "The larger ceratopsians, with their great horned heads, relied on active defensive strategies and presumably required somewhat greater agility than the tail-weaponed forms, both in fending off predators and in intraspecific combat bouts. The smaller ceratopsians, lacking true horns, would have relied on sensory acuity and speed to escape from predators." The ornithopods (duckbills and their allies) were the brainiest herbivores, with EQ's from 0.85 to 1.5. They relied upon "acute senses and relatively fast speeds" to elude carnivores. Flight seems to require more acuity and agility than standing defense. Among ceratopsians, small, hornless, and presumably fleeing *Protoceratops* had a higher EQ than great three-horned *Triceratops*.

Carnivores have higher EQ's than herbivores, as in modern vertebrates. Catching a rapidly moving or stoutly fighting prey demands a good deal more upstairs than plucking the right kind of plant. The giant theropods (*Tyrannosaurus* and its allies) vary from 1.0 to nearly 2.0. Atop the heap, quite appropriately at its small size, rests the little coelurosaur *Stenonychosaurus* with an EQ well above 5.0. Its actively moving quarry, small mammals and birds perhaps, probably posed a greater challenge in discovery and capture than *Triceratops* afforded *Tyrannosaurus*.

I do not wish to make a naive claim that brain size equals intelligence or, in this case, behavioral range and agility (I

don't know what intelligence means in humans, much less in a group of extinct reptiles). Variation in brain size within a species has precious little to do with brain power (humans do equally well with 900 or 2,500 cubic centimeters of brain). But comparison across species, when the differences are large, seems reasonable. I do not regard it as irrelevant to our achievements that we so greatly exceed koala bears —much as I love them—in EQ. The sensible ordering among dinosaurs also indicates that even so coarse a measure as brain size counts for something.

If behavioral complexity is one consequence of mental power, then we might expect to uncover among dinosaurs some signs of social behavior that demand coordination, cohesiveness, and recognition. Indeed we do, and it cannot be accidental that these signs were overlooked when dinosaurs labored under the burden of a falsely imposed obtuseness. Multiple trackways have been uncovered, with evidence for more than twenty animals traveling together in parallel movement. Did some dinosaurs live in herds? At the Davenport Ranch sauropod trackway, small footprints lie in the center and larger ones at the periphery. Could it be that some dinosaurs traveled much as some advanced herbivorous mammals do today, with large adults at the borders sheltering juveniles in the center?

In addition, the very structures that seemed most bizarre and useless to older paleontologists—the elaborate crests of hadrosaurs, the frills and horns of ceratopsians, and the nine inches of solid bone above the brain of *Pachycephalosaurus*—now appear to gain a coordinated explanation as devices for sexual display and combat. Pachycephalosaurs may have engaged in head-butting contests much as mountain sheep do today. The crests of some hadrosaurs are well designed as resonating chambers; did they engage in bellowing matches? The ceratopsian horn and frill may have acted as sword and shield in the battle for mates. Since such behavior is not only intrinsically complex, but also implies an elaborate social system, we would scarcely expect to find it in a group of animals barely muddling through at a moronic level.

But the best illustration of dinosaurian capability may well be the fact most often cited against them—their demise. Extinction, for most people, carries many of the connotations attributed to sex not so long ago—a rather disreputable business, frequent in occurrence, but not to anyone's credit, and certainly not to be discussed in proper circles. But, like sex, extinction is an ineluctable part of life. It is the ultimate fate of all species, not the lot of unfortunate and ill-designed creatures. It is no sign of failure.

The remarkable thing about dinosaurs is not that they became extinct, but that they dominated the earth for so long. Dinosaurs held sway for 100 million years while mammals, all the while, lived as small animals in the interstices of their world. After 70 million years on top, we mammals have an excellent track record and good prospects for the future, but we have yet to display the staying power of dinosaurs.

People, on this criterion, are scarcely worth mentioning —5 million years perhaps since *Australopithecus*, a mere 50,000 for our own species, *Homo sapiens*. Try the ultimate test within our system of values: Do you know anyone who would wager a substantial sum, even at favorable odds, on the proposition that *Homo sapiens* will last longer than *Brontosaurus*?