Despite their heft, many dinosaurs had surprisingly tiny genomes

March 7 2007

They might be giants, but many dinosaurs apparently had genomes no larger than that of a modern hummingbird.

So say scientists who've linked bone cell and genome size among living species and then used that new understanding to gauge the genome sizes of 31 species of extinct dinosaurs and birds, whose bone cells can be measured from the fossil record.

The researchers, at Harvard University and the University of Reading, were led by Chris Organ and Scott V. Edwards, both at Harvard. They report their findings this week in the journal *Nature*.

"We see distinct differences between two major lineages of dinosaurs," says Organ, a postdoctoral fellow in organismic and evolutionary biology supported by the National Institutes of Health. "The theropods -- carnivores such as Tyrannosaurus rex and Velociraptor -- had very small genomes, in the range of modern birds. Ornithischians -- which include Stegosaurus and Triceratops -- had more moderately sized genomes, akin to those of living lizards and crocodilians. We aren't sure about the genomes of the long-necked sauropods yet."

Organ and Edwards say the clear-cut dichotomy in dinosaur genomes is likely due to different amounts of repetitive and non-coding DNA in the two groups' genetic material, a factor largely responsible for variation in genome size across animal species. They estimate that active repetitive DNA might have comprised an average 12 percent of the ornithischian genome but just 8.4 percent of theropod genetic constitution.

The work indicates that the small genomes typically associated with birds -- whose genetic composition is noticeably sparer than that of other vertebrates -- evolved in dinosaurs some 230 to 250 million years ago, rather than with the emergence of modern living birds just 110 million years ago. Organ and Edwards suggest after this shrinking, theropod genomes then stabilized in size for hundreds of millions of years, a process that continues in modern birds.

"Our work debunks the theory that the small, repeat-poor genomes typical of birds may have co-evolved with flight as a means of conserving energy," says Edwards, professor of organismic and evolutionary biology in Harvard's Faculty of Arts and Sciences and Alexander Agassiz Professor of Zoology and curator of ornithology in Harvard's Museum of Comparative Zoology. "In fact, our work shows these streamlined genomes arose long before the first birds and flight, and can be added to the list of dinosaur traits previously thought to be found only in modern birds, including feathers, pulmonary innovations, and parental care and nesting."

Other researchers had previously determined that the sizes of various cell types, across species, tend to reflect the size of an organism's genome. Analyzing 26 living species, Organ and Edwards are the first to show that the same applies to the bone cells called osteocytes.

These cells reside in individual lacunae, small pockets inside bone tissue. This uniquely durable cellular housing allowed the scientists to look back in time at the size of 31 extinct species' genomes: By measuring lacunae in dinosaur and extinct bird specimens housed at Harvard's Museum of Comparative Zoology and at the Museum of the Rockies in Bozeman, Mont., they were able to determine just how big the various extinct species' osteocytes had been.

"These fossils let us sample species through evolutionary time," Edwards says, "providing genomic information that's often unavailable for long-extinct ancestors."

Source: Harvard University