PALEOANTHROPOLOGY

# Bone Sizes Trace the Decline Of Man (and Woman)

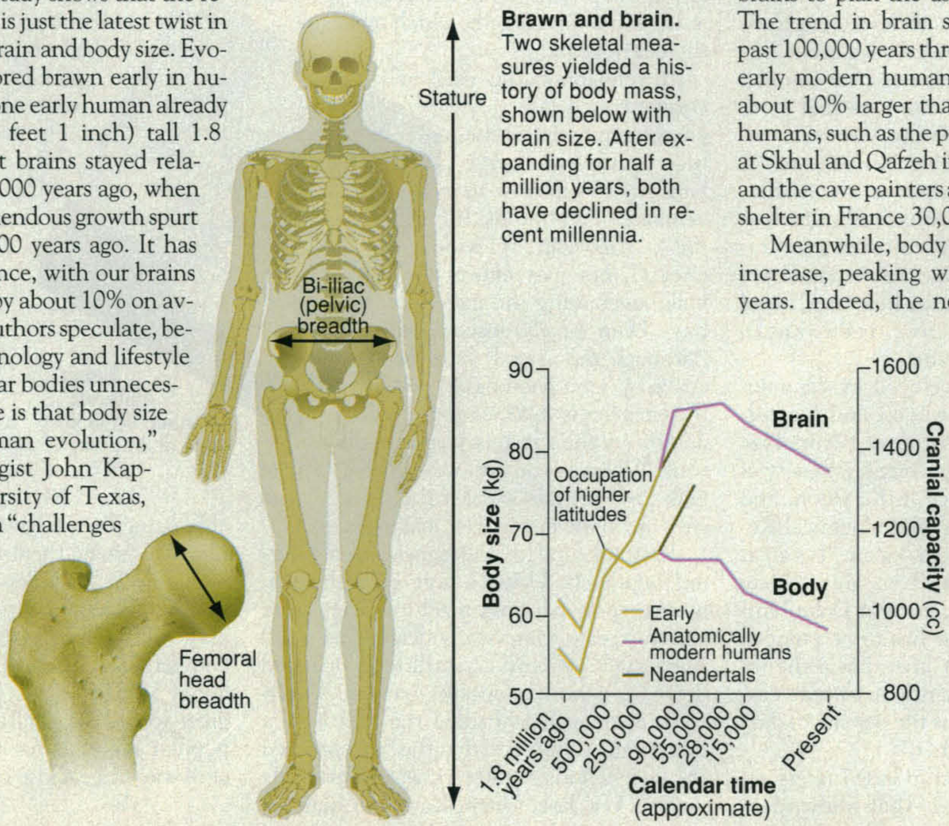
When paleontologist Stephen J. Gould teaches his history of life course to Harvard undergraduates, he flashes slides from popular media that depict human ancestors marching through time. The earliest members of our genus, *Homo*, appear short and stooped, but as time passes, our forebears gradually grow taller and bigger brained. The march of progress culminates in the implicit masterpiece of evolution—big-brained, upright, modern humans.

But this popular view of human evolution is wrong, says Gould, who is the most visible critic of the long-standing notion that our lineage evolved gradually and inexorably toward a bigger, brainier human. Compelling proof that he's right has now come from the fossil record. In the 8 May issue of *Nature*, a new study of the bones of 163 early members of *Homo* who lived 2 million to 10,000 years ago suggests that our bodies—and brains—have gotten smaller lately, not bigger. Anthropologists have long thought that some members of the *Homo* lineage, the Neandertals, were brawnier than we are, but the new study, based on skull volume and two skeletal indicators of body mass, shows that the same was true of our direct ancestors.

What's more, the study shows that the recent downsizing trend is just the latest twist in a complex history of brain and body size. Evolution apparently favored brawn early in human history: At least one early human already stood 1.85 meters (6 feet 1 inch) tall 1.8 million years ago. But brains stayed relatively small until 600,000 years ago, when they underwent a tremendous growth spurt that lasted until 50,000 years ago. It has been downhill ever since, with our brains and bodies shrinking by about 10% on average—perhaps, the authors speculate, because changes in technology and lifestyle have rendered muscular bodies unnecessary. "The bottom line is that body size did vary through human evolution," says paleoanthropologist John Kappelman of the University of Texas, Austin. That variation "challenges the traditional view that living humans are the epitome of large body and brain size," says Christopher Ruff, a biological anthropologist at Johns Hopkins University and the study's lead author.

Putting that view to the test has been difficult because anthropologists can't measure early humans from head to toe, or "even from pelvis to toe," says Ruff, as the fossils from any one skeleton are too fragmentary. As a result, researchers have tried indirect means of estimating body size, such as skull thickness or tooth and eye-socket size. These methods, however, have proven to be unreliable, probably because factors such as activity, diet, or climate can also influence them, says Ruff. For the past decade, he has been trying to find better measures.

One feature that seems to fit the bill is the head of the femur, or thighbone. In studies of living humans, Ruff and others have found that the breadth of this femoral head is proportional to the mass of a person's body—the bigger the body, the bigger the femoral head supporting its weight—and they have developed equations that express the relation. A team including Ruff and paleoanthropologists Erik Trinkaus of the University of New Mexico and Trenton Holliday of the College of William and Mary in Williamsburg, Virginia, has now applied this equation to fossil femora from 93 individuals.




**Brawn and brain.** Two skeletal measures yielded a history of body mass, shown below with brain size. After expanding for half a million years, both have declined in recent millennia.

To check their results, Ruff and colleagues used a second method for estimating body mass based on stature, which they gauged from the length of limb bones, and on the breadth of the pelvis, as measured (or estimated) between the two widest points of the flaring iliac bones. They applied this measure to 96 fossils (including 26 for which they also had femoral heads) and got results that closely matched those based on the femoral head. The agreement "helped increase my confidence that we were getting fairly unbiased estimates of body weight," says Ruff. Finally, they compared those estimates with their own and others' published measurements or estimates of cranial capacity to get brain size relative to body size.

In an earlier, less comprehensive study with Pennsylvania State University paleoanthropologist Alan Walker, Ruff had found that one *H. erectus* fossil, the 1.5 million year old Nariokotome boy who lived near Lake Turkana in Kenya, would have stood 1.85 meters (6 feet 1 inch) tall and weighed 71 kilograms (156 pounds) if he had reached adulthood. The new study confirmed that six-footers were already striding around east Africa at that time, but their brains were about two-thirds the size of ours—and stayed that size for a million years.

The stasis ended when "there was a truly extraordinary increase in brain size from about 600,000 to 30,000 years ago," says Trinkaus. This coincides, he notes, with the expansion of early humans to colder climates, which could have reinforced selection for larger brains to plan the use of seasonal resources. The trend in brain size continued over the past 100,000 years through the Neandertals to early modern humans. Brain size peaked at about 10% larger than ours in early modern humans, such as the people who lived in caves at Skhul and Qafzeh in Israel 90,000 years ago and the cave painters at the Cro-Magnon rock shelter in France 30,000 years ago.

Meanwhile, body size continued a slower increase, peaking within the last 100,000 years. Indeed, the new analysis shows that Neandertals were the champions of brawn, outweighing contemporary humans by 30%. Their brains were also larger than ours in absolute terms, but their ratio of brain size to body mass was about 10% lower. This finding solves an important mystery—why Neandertals' activities don't look particularly intelligent in the fossil record, despite their big brains: "People always go on about Ne-

SOURCE: CHRISTOPHER RUFF ILLUSTRATION: K. SUTLUFF andertals having larger brains than ours, but this disproves that if you take into account body size," says Leslie Aiello of University College London. In a commentary in *Nature*, Kappelman suggests that the result will require "critical re-thinking" about the behavior of Neandertals, implying that it "was probably decidedly non-modern—and more dependent on brawn than brains."

The decline in both brain and body size since the days of the Neandertals and Cro-Magnons may be due to tools or social skills that reduced our ancestors' reliance on sheer brawn, says Ruff. And as the body shrank, so did the brain. Trinkaus points out other factors that may have contributed to the trend in recent millennia: for example, poor nutrition as agriculture replaced the varied fare of hunter-gatherers with a poorer diet. Other researchers have found that stature was smallest in the Neolithic and Middle Ages, although Ruff suggests that better nutrition has allowed some populations to bounce back to their Pleistocene heights, including Americans and northern Europeans.

Kappelman and Richard Smith of Washington University in St. Louis believe that the trends in brain and body size that the Ruff study has traced are real. They are less convinced by Ruff's absolute values for body mass, however, because he calibrated his equations on living humans. The modern, sedentary lifestyle may have thrown off the relation between body mass and skeletal features. Kappelman suggests that athletes might be a better basis for the equations.

But those concerns, he adds, won't affect the most important conclusions. Body and brain size reflect the different ways our ancestors adapted to their environments—suggesting that "they were behaving differently than us," says Kappelman. And, as far as the human physique goes, the march of progress is definitely a myth.

**–Ann Gibbons**

ASTRONOMY

# Antimatter Hints at Galactic Turmoil

WILLIAMSBURG, VIRGINIA—Compared with some of the universe's more turbulent neighborhoods, the Milky Way is a tranquil suburb. But last week's announcement here that the orbiting Compton Gamma-Ray Observatory (CGRO) had spotted a wayward cloud of positrons—the antimatter equivalent of electrons—near the galactic center hinted that, like many suburbs, the galaxy is not as placid as it seems.

Some astronomers are speculating that the cloud may be a legacy of thousands of stellar explosions that rocked the galactic center about 10 million years ago, creating positrons and driving them outward. It's not the only possible explanation, and it received mixed reviews at the Fourth Compton Symposium on Gamma-Ray Astronomy and Astrophysics, where the cloud was announced. "It's a neat discovery," says Neil Gehrels, an astrophysicist at the NASA Goddard Space Flight Center in Greenbelt, Maryland, but the supernova scenario "is a bit of a stretch" because it requires the fragile antimatter particles to survive a long trip through space. But whatever the cloud's true story turns out to be, it is likely to leave the galaxy looking more tumultuous than before.

The positrons prompting this new view of the galactic center can be seen only when they meet with electrons in a violent encounter that annihilates both particles, producing gamma rays concentrated at an energy of 511 kiloelectron volts. Since the 1970s, detectors lofted by balloons and satellites above Earth's gamma-ray–absorbing atmosphere have picked up this death cry coming from the center of the galaxy. Astronomers speculated that the massive black holes thought to lurk there were responsible: They theorized that matter is superheated as it falls into the black holes, generating gamma rays that collide and spawn positron-electron pairs.

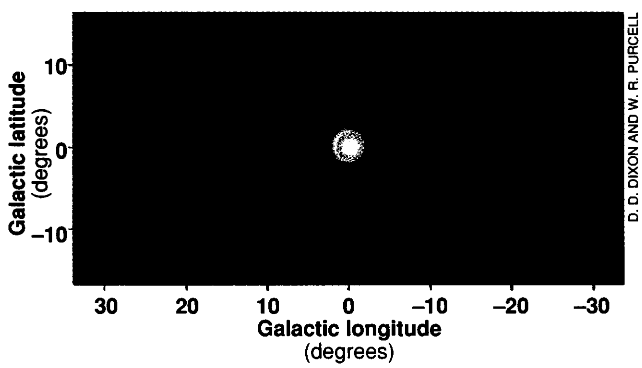
These instruments yielded only rough indications of the amount and location of the positrons. After NASA launched the CGRO in 1991, astrophysicists set out to use the satellite's Oriented Scintillation Spectrometer Experiment (OSSE), which has a finer spatial resolution than its predecessors, to pin down the precise locations of the antimatter. But when OSSE searched near the center of the galaxy, it found only about half of the positrons tallied earlier.

So the researchers, led by astrophysicists William Purcell of Northwestern University and James Kurfess of the Naval Research Laboratory (NRL) in Washington, D.C., broadened their search. They have now found the missing positrons in an unlikely spot—about 3000 light-years above the galactic center. "We were very surprised to see this," Purcell says, because the region appears to lack any sign of a black hole or other positron source.

Some researchers argue that a black-hole source may yet be discovered. But Charles Dermer and Jeff Skibo of the NRL are skeptical. For one thing, they say, black holes hiccup out positrons, as clumps of matter fall in, but months of OSSE observations haven't detected any variation in the amount of antimatter.

Dermer and his colleagues envision a different source: supernovae at the center of the galaxy. Exploding stars make radioactive isotopes that emit positrons as they decay. And a volley of supernovae sometime in the last 10 million years could have turned the galactic center into "a cauldron of violence," says Dermer, propelling "a fountain of hot gas" that would have swept the positrons out of the galactic plane.

The picture has some observational support. Astronomers have seen chimneys of hot gas escaping from the galactic disk, presumably powered by supernovae. And glimpses of the dust-shrouded galactic center have revealed hints of turmoil there. Radio emissions suggest a flow of gas streaming in the general direction of the cloud. X-ray observations also suggest that the ionized gas there has been heated to 10 to 100 million degrees or more by past violence. The annihilation fountain, says Dermer, "knits together those observations into a coherent picture."




**Misplaced antimatter.** A gamma-ray map of the center of the galaxy traces the antimatter fountain.

The model faces some difficulties, however, including the question of how the positrons get so far from the galactic center without encountering matter and annihilating. Astronomers also wonder whether the Milky Way was capable of forming massive stars—the kind that explode—fast enough to explain the burst of supernovae. But Dieter Hartmann, an astrophysicist at Clemson University in South Carolina, says that while "there's no rigorous, solid evidence" of such a starburst, "the assumptions are reasonable."

Perhaps the biggest question is whether the antimatter cloud really does hover over the galactic center, because the gamma rays do not reveal the distance of the positrons. If its apparent link to the center turns out to be just a chance alignment, the hunt will be on for other pockets of violence in our quiet cosmic suburb.

**–Erik Stokstad**