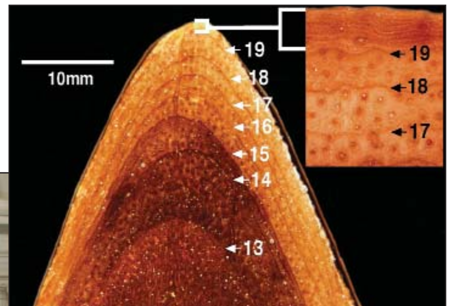
PALEONTOLOGY

Bone Study Shows *T. rex* Bulked Up With Massive Growth Spurt

Tyrannosaurus rex was a creature of superlatives. As big as a bull elephant, *T. rex* weighed 15 times as much as the largest carnivores living on land today. Now, paleontologists have for the first time charted the colossal growth spurt that carried *T. rex* beyond its tyrannosaurid relatives. "It would have been the ultimate teenager in terms of food intake," says Thomas Holtz of the University of Maryland, College Park.

Growth rates have been studied in only a half-dozen dinosaurs and no large carnivores. That's because the usual method of telling ages—counting annual growth rings in the leg bone—is a tricky task with tyrannosaurids. "I was told when I started in this field that it was impossible to age *T. rex*," recalls Gregory Erickson, a paleobiologist at Florida State University in Tallahassee, who led the study. The reason is that the weight-bearing bones of large dinosaurs become hollow with age and the internal tissue tends to get remodeled, thus erasing growth lines.



Hungry. Growth rings (*inset*) in a rib show that Sue grew fast during its teenage years.

But leg bones aren't the only place to check age. While studying a tyrannosaurid called *Daspletosaurus* at the Field Museum of Natural History (FMNH) in Chicago, Illinois, Erickson noticed growth rings on the end of a broken rib. Looking around, he found similar rings on hundreds of other bone fragments in the museum drawers, including the fibula, gastralia, and the pubis. These bones don't bear substantial loads, so they hadn't been remodeled or hollowed out.

Switching to modern alligators, crocodiles, and lizards, Erickson found that the growth rings accurately recorded the animals' ages. He and his colleagues then sampled more than 60 bones from 20 specimens of four closely related tyrannosaurids. Counting the growth rings with a microscope, the team found that the tyrannosaurids had died at ages ranging from 2 years to 28.

By plotting the age of each animal against its mass—conservatively estimated from the circumference of its femur—they constructed growth curves for each species. *Gorgosaurus* and *Albertosaurus*, both more primitive tyrannosaurids, began to put on weight more rapidly at about age 12. For 4 years or so, they added 310 to 480 grams per day. By about age 15, they were full-grown at about 1100 kilograms. The more advanced *Daspletosaurus* followed the same trend but grew faster and maxed out at roughly 1800 kilograms.

T. rex, in comparison, was almost off the chart. As the team describes this week in *Nature*, it underwent a gigantic growth spurt starting at age 14 and packed on 2 kilograms a day. By age 18.5 years, the heaviest of the lot, FMNH's famous *T. rex* named Sue, weighed more than 5600 kilograms. Jack Horner of the Museum of the Rockies in Bozeman, Montana, and Kevin Padian of the University of California, Berkeley, have found the same growth pattern in other specimens of *T. rex*. Their paper is in press at the *Proceedings of the Royal Society of London*, Series B.

It makes sense that *T. rex* would grow this way, experts say. Several lines of evidence suggest that dinosaurs had a higher metabolism and faster growth rates than living reptiles do (although not as fast as birds'). Previous work by Erickson showed that young dinosaurs stepped up the pace of growth, then tapered off into adulthood; reptiles, in contrast, grow more slowly, but they keep at it for longer. "*Tyrannosaurus rex* lived fast and died young," Erickson says. "It's the James Dean of dinosaurs."

Being able to age the animals will help shed light on the population structure of tyrannosaurids. For instance, the researchers determined the ages of more than half a dozen Albertosaurs that apparently died ▶

PLANETARY SCIENCE

Los Alamos's Woes Spread to Pluto Mission

The impact of the shutdown of Los Alamos National Laboratory in New Mexico could ripple out to the distant corners of the solar system. The lab's closure last month due to security concerns (*Science*, 23 July, p. 462) has jeopardized a NASA mission to Pluto and the Kuiper belt. "I am worried," says S. Alan Stern, a planetary scientist with the Southwest Research Institute in Boulder, Colorado, who is the principal investigator.

That spacecraft, slated for a 2006 launch, is the first in a series of outer planetary flights. In those far reaches of space, solar power is not an option. Instead, the mission will be powered by plutonium-238, obtained from Russia and converted by Los Alamos scientists into pellets. But the 16 July "stand down" at the lab has shut down that effort, which already was on a tight schedule due to the lengthy review required for any spacecraft containing nuclear material.

The 2006 launch date was chosen to make use of a gravity assist from Jupiter to rocket the probe to Pluto by 2015. A 1-year delay could cost an additional 3 to 4 years in transit time. "It won't affect the science we will be able to do in a serious way, but it will delay it and introduce risks," says Stern. Some researchers fear that Pluto's thin atmosphere could freeze and collapse later in the next decade, although the likelihood and timing of that possibility are in dispute.

Los Alamos officials are upbeat. "Lab activity is coming back on line," says spokesperson Nancy Ambrosiano. Even so, last week lab director George "Pete" Nanos suspended four more employees in connection with the loss of several computer disks containing classified information, and Nanos says that it could take as long as 2 months before everyone is back at work. NASA officials declined comment, but Stern says "many people are working to find remedies."

–ANDREW LAWLER

CREDITS: THE FIELD MUSEUM

together. They ranged in age from 2 to 20 in what might have been a pack. "You've got really young living with the really old," Erickson says. "These things probably weren't loners."

The technique could also help researchers interpret the medical history of individuals. Sue, in particular, is riddled with pathologies, and the growth rings might reveal at what age various kinds of injuries occurred. "We could see if they had a really rotten childhood or lousy old age," Holtz says. And because a variety of scrap bones can be analyzed for growth rings, more individuals can be examined. "Not many museums will let you cut a slice out of the femur of a mounted specimen," notes co-author Peter Makovicky of FMNH. "A great deal of the story about Sue was still locked in the drawers," Erickson adds.

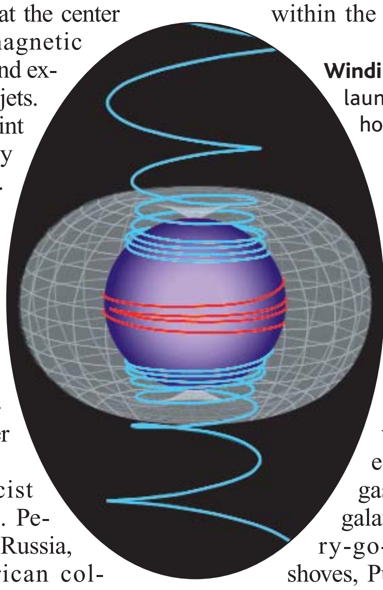
–ERIK STOKSTAD

ASTROPHYSICS

Do Black Hole Jets Do the Twist?

Among the dark secrets that nestle in galactic cores, one of the most vexing is how the gargantuan energy fountains called radio-loud quasars propel tight beams of particles and energy across hundreds of thousands of light-years. Astrophysicists agree that the power comes from supermassive black holes, but they differ sharply about how the machinery works. According to a new model, the answer might follow a familiar maxim: One good turn deserves another.

On page 978, three astrophysicists propose that a whirling black hole at the center of a galaxy can whip magnetic fields into a coiled frenzy and expel them along two narrow jets. The team's simulations paint dramatic pictures of energy spiraling sharply into space. "It has a novelty to it—it's very educational and illustrative," says astrophysicist Maurice van Putten of the Massachusetts Institute of Technology in Cambridge. But the model's simplified astrophysical assumptions allow other explanations, he says.



Winding up. Coiled magnetic fields launch jets from massive black holes, a model claims.

CREDIT: V. SEMENOV *ET AL.*

The paper, by physicist Vladimir Semenov of St. Petersburg State University, Russia, and Russian and American colleagues, is the latest word in an impassioned debate about where quasars get their spark. Some astrophysicists think the energy comes from a small volume of space around the black holes themselves, which are thought to spin like flywheels weighing a billion suns or more. Others suspect the jets blast off from blazingly hot "accretion disks" of gas that swirl toward the holes. Astronomical observations aren't detailed enough to settle the argument, and computer models require a complex mixture of general relativity, plasma physics, and magnetic fields. "We're still a few years away from realistic time-dependent simulations," says astrophysicist Ken-Ichi Nishikawa of the National Space Science and Technology Center in Huntsville, Alabama.

Semenov and his colleagues depict the churning matter near a black hole as individual strands of charged gas, laced by strong magnetic lines of force. Einstein's equations of relativity dictate the outcome, says co-author Brian Punsly of Boeing Space and Intelligence Systems in Torrance, California. The strands get sucked into the steep vortex of spacetime and tugged around the equator just outside the rapidly spinning hole, a relativistic effect called frame dragging. Tension within the magnetized ribbons keeps them intact. Repeated windings at close to the speed of light torque the stresses so high that the magnetic fields spring outward in opposite directions along the poles, expelling matter as they go.

The violent spin needed to drive such outbursts arises as a black hole consumes gas at the center of an active galaxy, winding up like a merry-go-round getting constant shoves, Punsly says. In that environment, he notes, "Frame dragging dominates everything."

Van Putten agrees, although his research suggests that parts of the black hole close to the axis of rotation also play a key role in forming jets by means of frame dragging.

Still, the basic picture—a fierce corkscrew of magnetized plasma unleashed by a frantically spinning black hole—is valuable for quasar researchers, says astrophysicist Ramesh Narayan of the Harvard-Smithsonian Center for Astrophysics in Cambridge. "This gives me a physical sense for how the black hole might dominate over the [accretion] disk in terms of jet production," he says.

–ROBERT IRION

ScienceScope

Hubble Space Telescope Loses Major Instrument

One of the four main instruments on the aging Hubble Space Telescope has failed, due to an electrical fault in its power system. It will take several weeks to determine whether the Space Telescope Imaging Spectrograph (STIS) is truly deceased, but officials have slim hopes of recovery, noting that even a shuttle repair mission couldn't revive it. "It doesn't look good," says Bruce Margon, the associate director for science at the Space Telescope Science Institute in Baltimore, Maryland.

STIS, which splits incoming light into its component colors, is particularly useful for studying galaxy dynamics, diffuse gas, and black holes. Although STIS measurements account for nearly one-third of this year's Hubble science portfolio, Margon says that the telescope still has plenty of work it can do. "It will be no effort at all to keep Hubble busy," says Margon, although it is a "sad and annoying loss of capability. … It's a bit like being a gourmet chef and being told you can never cook a chicken again."

–CHARLES SEIFE

Britain to Consider Repatriating Human Remains

The British government is requesting public comment on a proposal that could require museums and academic collections to return human remains collected around the world. Department for Culture officials last month released a white paper (www.culture.gov.uk/global/consultations) recommending that scientists identify how bones or tissues became part of their collections and seek permission from living descendants to keep identifiable remains for study. It also calls for licensing institutions that collect human remains.

Indigenous groups have long campaigned for such measures, saying that anthropologists and others have collected remains without permission. But some scientists worry that the move could harm research by putting materials out of reach and lead to expensive legal wrangles over ownership. Society needs to "balance likely harm against likely benefit," says Sebastian Payne, chief scientist at English Heritage in London, adding that "older human remains without a clear and close family or cultural relationship" are probably best left in collections. Comments are due by 29 October.

–XAVIER BOSCH