diles. Birds have no such separation.

In living crocodilians, the function of this separation is to provide an airtight seal between the cavities. Then, when the diaphragmatic muscles contract, they pull back the liver and create negative pressure in the thoracic cavity, allowing air to fill the bellows-type lungs. Birds don't need such a separation between the cavities, because air in their lungs moves one way through millions of tiny air passages, drawn by the expansion and contraction of air sacs throughout their bodies.

Birds' flow-through lung system has plenty of surface area and is especially efficient at exchanging oxygen for carbon dioxide. (Mammals have yet another system that allows efficient gas exchange.) The bellowslike reptilian lung, however, provides much less area for gas exchange, and reptiles cannot absorb oxygen at the high rates needed to sustain intense activity. Ruben also showed that theropods and crocodiles share a distinct hip structure, linked to muscles that help bring air into the bellowslike lungs. All in all, says Ruben, it's "pretty solid evidence that theropods could not have had a modern, high-performance avian-style lung … and were stuck with an unmodified, bellowslike lung." Says Martin: "Support for the hot-blooded dinosaur hypothesis now has the rigidity of a marshmallow." The evolutionary implications are even more far-reaching. Ruben argues that a transition from a crocodilian to a bird lung would be impossible, because the transitional animal would have a life-threatening hernia or hole in its diaphragm. "There may well be a relationship between dinosaurs and birds, but it's not the linear relationship you see in museum displays," he says.

Ruben's analysis is "another nail in the coffin of the warm-blooded dinosaur theory," says paleontologist Peter Dodson of the University of Pennsylvania, Philadelphia. But many other researchers say his case is not airtight. They point out that Ruben relied on photos showing a lung outline that is little more than "smudges on rock," says Witmer. What's more, Ruben's inferences are based on a flattened, two-dimensional fossil. "You would expect some deformation when the organs squish out," says Witmer, who suggests, only half-jokingly, that Ruben flatten his alligators with a steamroller for comparison. And the evolutionary transition from the actual theropod lung, rather than the modern crocodilian analog, might be easier.

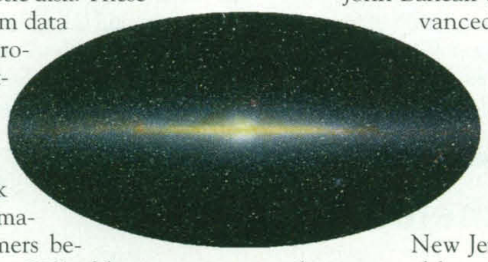
Indeed, even if Ruben's analysis of lung structure holds up, it would have to be weighed against "a mountain" of other evidence supporting the dinosaurian origin of birds, says Farlow. Still, he finds Ruben's findings of a crocodilian-type lung for theropods "compelling." Fortunately, the Yixian formation is so rich in fossils that more specimens of *Sinosauropteryx* are likely to turn up. And if the same lung structure appears in enough fossils, Ruben's case will gather considerable weight.

–Ann Gibbons

ASTRONOMY

Galactic Disk Contains No Dark Matter

By studying the movement of stars in the disk of our Milky Way galaxy, two teams of French astronomers have concluded that what you see is what you get: The mass of the visible stars appears to account for all the material in the galactic disk. These findings, derived from data gathered by the European astrometric satellite Hipparcos, imply that the main body of our galaxy contains no "dark matter"—invisible material that astronomers believe accounts for up to 90% of the mass of the universe. "These studies confirm that the dark matter [presumed to be] associated with the galactic disc in fact doesn't exist," says Honc-Anh Pham of the Paris Observatory at Meudon, whose doctoral thesis forms one of two studies that came to this conclusion. Instead, both groups argue, the dark matter must be lurking in the galactic halo, a large, spherical region encircling the galaxy containing dust, gas, and globular clusters of very old stars.



NASA

No more than meets the eye. Visible stars seem to account for all the mass in the galactic disk.

Pham studied the movements of 10,000 stars to get a fix on the gravitational forces pulling them around. She inferred from these movements that the local mass density in our galaxy is 0.11 solar masses per cubic parsec. (A parsec corresponds to 3.26 light-years.) A separate team, led by Michel Crézé of Strasbourg Observatory, reports in a forthcoming issue of *Astronomy & Astrophysics* that from a study of a smaller group of 100 stars they found an even lower value, 0.076 solar masses per cubic parsec. These values are close to estimates of the mass density of visible stars in the galactic disk and leave little room for dark matter. The new results confirm some earlier estimates, made before Hipparcos data became available, but they are much lower than values obtained by John Bahcall of the Institute for Advanced Study in Princeton, New Jersey, using velocity data from ground-based astrometric observations. He concluded that the local galactic density is between 0.15 and 0.20, enough to accommodate 30% to 50% dark matter.

Astronomers have long surmised that dark matter provides some of the gravitational glue required to hold galaxies together: Most galaxies rotate so fast that they would fly apart if their visible stars provide the only sources of gravity. The stars in galaxies also orbit in a peculiar fashion: Unlike planets in the solar system, stars in the outer reaches of galaxies move as fast as those nearer the center. This suggests that the galaxies' mass must be spread out and not concentrated in the core, as it is in the solar system.

Astronomers can estimate the total mass in a galaxy like our own from the forces needed to hold it together, but without an accurate knowledge of the mass density of the galactic disk, they could not tell how much of the dark matter resides in the disk and how much in the halo, Crézé says.

Crézé and his Strasbourg colleagues Emmanuel Chereuil and Olivier Bienaymé, and Christophe Pichon of the University of Basel in Switzerland, looked at the Hipparcos data for 100 stars in a sphere of radius 125 parsecs around the sun. Hipparcos, launched in August 1989, cataloged over 4 years the precise position and motions of more than 100,000 stars. The team analyzed the distribution of the motions of their sample of "tracer" stars in the direction perpendicular to the galactic disk to assess the amount of gravitational pull dragging them back toward the galactic plane. Herwig Dejonghe of the University of Ghent in Belgium compares their method to "looking at a sample of high jumpers and deducing the mass of the Earth from the height they reach."

Pham's approach was somewhat different: Her larger sample within a sphere with radius 250 parsecs consisted of just one type of star, known as F-type, which are old and so have dissipated some of the motion associated with their births in swirling clouds of gas. From their distance from the galactic plane and their proper motions, she obtained her value of the local galactic density.

The results were welcomed by Michael Merrifield of Britain's Southampton University, who with his colleague Robert Olling has argued from observations of the shape of the galactic disk, that all the dark matter in the galaxy should be found in a round halo. "We actually have run calculations … our [galactic] model with the round halo corresponds exactly to the kind of numbers they get," Merrifield says.

–Alexander Hellemans

Alexander Hellemans is a writer in Naples, Italy.