signature of methane. Adds Liebert, who chaired the session, "The methane spectrum proves beyond a shadow of a doubt that this object is way below the mass of a [main-sequence] star."

Yet it's not a planet, say researchers. The older and smaller a brown dwarf is, the dimmer its light. By assuming that the age estimated for the main star also applies to the smaller companion, Oppenheimer and his colleagues were able to come up with an estimate of its mass: at least 20 times that of Jupiter. At that size, says Peter Bodenheimer of Lick Observatory at the University of California, Santa Cruz, "it's extremely unlikely that it formed in a planet mode"—as a rock and ice core that grew as it swept up gases from a protoplanetary disk around the main star. Such a process is thought to be self-limiting: By the time the planet reaches a size somewhat larger than Jupiter, it has swept out a big enough gap in the disk to shut down the growth process.

Bodenheimer says the object is more likely to have formed as a star does, at the center of a collapsing nebula. Either a fragment of the main stellar nebula or a new nebula spawned when a gravitational instability ripped away part of the circumstellar disk could have given birth to it, he says. Such possibilities should give theorists who model star formation plenty of work as they try to reproduce the object's mass and orbit around the companion star.

The detection of methane, along with other features of the spectrum such as a hint of water, should also provide a new reality test for theorists trying to explain the structure and composition of atmospheres in objects as different as Jupiter and brown dwarfs. And for brown-dwarf hunters, Kulkarni says, the methane could mean an end to having to limit their searches to companion stars or dim members of clusters; instead, they can simply screen dim objects for the gas's signature.

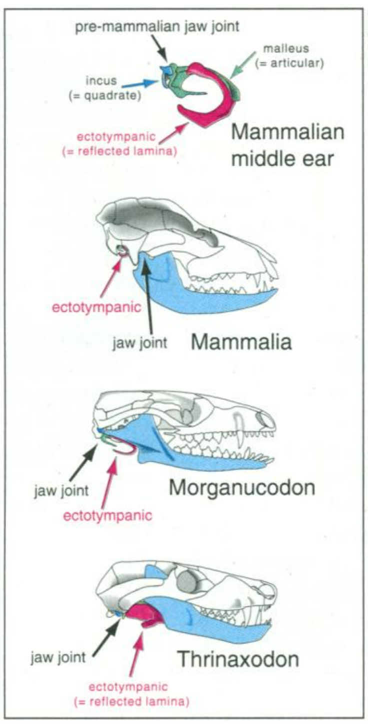
But unless such searches boost the brown dwarf population dramatically, everyone agrees that they won't account for the universe's dark matter. "We looked at 100 stars and we found one interesting guy," says Kulkarni. "That doesn't add much to the dark-matter problem."

–James Glanz

PALEONTOLOGY

# Why Mammal Ears Went on the Move

The mark of a mammal is a migrating ear. About 160 million years ago, a chain of small bones that formed the hinge attaching jaw and skull in mammal ancestors moved back along the skull. The journey spanned just a few centimeters, but it sets true mammals apart from every other vertebrate. Freed of their hinge function, these bones teamed up with the inner ear to form a delicate sound-amplifying system known as the modern middle ear, and no nonmammal has it. Yet researchers have not been sure why this unique trip took place.




**Relocation.** The middle ear began as part of the jaw in mammal ancestors such as *Thrinaxodon* and gradually traveled back on the skull.

At last month's meeting of the Society of Vertebrate Paleontology in Pittsburgh, however, Timothy Rowe of the University of Texas, Austin, argued that bigger brains made these jaw bones jump. Based on the skull anatomy of mammal ancestors, Rowe reported that the migration of the ears coincided with the emergence of the neocortex and a prolonged period of brain growth. In a process replayed in the development of living mammals, he said, these bones were torn away from the jaw by the skull as it expanded to hold the bigger brain, freeing them to become optimized for hearing.

His colleagues seemed taken by the idea. "That was a fantastic talk," says Zhexi Luo, a biologist at the College of Charleston in South Carolina who studies ear evolution. "Rowe pointed out that detachment is a secondary effect of brain evolution. In the past it's only been considered in terms of jaw and associated ear bones." Researchers had theorized that the jaw bones in question were already being modified to enhance their role in hearing, he says, but the brain change helps explain the actual move. Says paleontologist William Clemens of the University of California, Berkeley: "It comes together as a neat hypothesis."

Ear migration actually occurs in every developing mammal. Three tiny pieces of bone begin developing along the lower jaw soon after conception. After several weeks, however, they are torn loose from their moorings and resettle at the entrance to the inner ear. One piece becomes the incus, or anvil, another becomes the malleus, or hammer, and the third becomes a bony ring called the ectotympanic, which holds the eardrum. Sound waves strike the eardrum, and the vibrations are then transmitted along the other bones to the inner ear.

Researchers, notably Edgar Allin of Midwestern University in Chicago, have argued that in evolutionary terms, this transformation began in mammal ancestors known as synapsids. Over 200 million years ago, synapsids began shrinking, going from dog-sized to shrew-sized, becoming nocturnal, and adopting a diet of insects. Allin noted that the smaller jaw bones, called auditory ossicles, already formed a chain that contacted the inner ear as well as the jaw joint. These bones were shrinking and becoming lighter as well, and Allin suggested they had begun to do double duty: picking up higher frequency sounds made by insects as well as hinging the jaw.

The question, says Rowe, is why they didn't go on bridging the gap between jaw and inner ear. The answer, he says, is that they could no longer reach. Rowe's examination of the skulls of mammal precursors revealed marks of a burgeoning neocortex. By the time of the first true mammals, this new structure had nearly doubled brain volume. This bigger brain, he suggests, keeps growing after the ossicles have stopped. Rowe's CT scans of a developing *Monodelphis*, a primitive, opossumlike mammal, show the auditory ossicles reach their maximum size 3 weeks after conception. But the brain and skull keep growing for another 9 weeks. The expanding arc between the jaw joint and the inner ear tears the ossicles away from the jaw, carrying them backward.

Allin agrees that brain growth in early mammals could have triggered the migration, although he emphasizes that his scenario is a prerequisite: First, the ossicles had to have become specialized for hearing, or in the tug of war between jaw and ear, evolutionary pressure would have kept them with the jaw joint. Removal from the jaw was a further sign of this evolutionary selection for hearing ability—it's hard to hear when you're chewing. Rowe and Clemens agree. "You could have a series of stepwise interactions between development and selection," Clemens says. The next step for understanding mammals, the paleontologists say, is to figure out what drove the development of the brain.

–Joshua Fischman