transitive reasoning; the researchers might then test for that with psychological exams designed for preverbal children.

Hype and bust?

Some admire Brooks and his colleagues for trying to shake up the community, as he did with the insect robots. "I think he wants to knock people on the side of the head again," says Grupen. Jill Lehman, an AI researcher at Carnegie Mellon University in Pittsburgh, suggests Cog is the perfect response to those who argue that researchers must integrate their successes in vision, hearing, and other relevant fields. "Someone has to try this. It's time now to stop working on the tiny little pieces and put them together," she says.

Yet others are already chalking Cog up as another blip in the disturbing "hype and bust" cycle of AI research, where overeager scientists promise to solve the mysteries of intelligence in order to attract funding for elaborate projects—projects that, inevitably, fail to deliver. "It's sexier if you build a robot, but it's not clear it's science. AI should be more disciplined, more issue-oriented, more patient," says Steven Pinker, a linguistics expert in MIT's cognitive science department. "There's so little known about the early stages of cognition that it's kind of silly to spend hundreds of thousands a year to simulate what we don't know. It's a waste of time," adds University of Rochester's Thomas Bever, an editor of the international journal *Cognition*.

While the Cog team shrugs off such criticism, Bever's mention of money does raise an issue that may ultimately stunt Cog's development. Until now, the project has largely been financed through a nest egg of unrestricted grants that Brooks had built up, but that reservoir will not last forever, he says. A first try with a large grant proposal at the National Science Foundation failed, they say, despite encouraging reviews. "The one big thing against us, in the current funding environment, is that this is not an application-driven program," explains Brooks, decrying what he calls the narrowing vision of U.S. funding agencies. "I believe Cog will have practical spin-offs, but Cog is not about practical spin-offs. Cog is about basic research with long-term strategic goals," adds an even more frustrated Stein.

Like worried parents, the two want the resources to bring their child up right. And like realistic parents, they expect Cog's life to include failure along with success. "We're overreaching; I'm perfectly willing to admit that," says Brooks. "We will fail in many dimensions," he adds, "but I think there's enough there to succeed a little bit in some dimensions." He and Stein just hope that Cog quickly learns from its mistakes—and in the process, educates its own parents about where they went wrong in raising it.

–John Travis

ANTHROPOLOGY

Putting a New Spin on the Birth of Human Birth

Humans do any number of things better than other animals, but giving birth is not one of them. Among the apes, our closest relatives, females bring infants into the world through a roomy birth canal with little fuss. In contrast, human babies often spend hours corkscrewing their way down a narrow birth canal, finally emerging head down, away from the mother—the only primates to do so. That makes human birth a risky business. Because babies don't bend backward, mothers can't pull them out without risk of serious injury, nor can they clear their newborns' airways if they are in trouble. Says University of Delaware anthropologist Karen Rosenberg wryly, "it's not the type of system you would invent if you were designing it today."

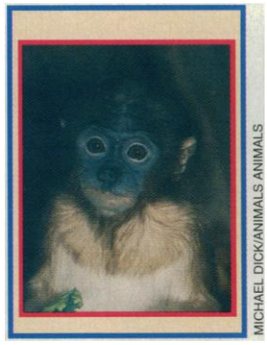
The process wasn't invented today, of course; it evolved over millions of years. But exactly when and how it did so has for decades perplexed anthropologists, who lacked the fossil evidence that could answer those questions. Over the past 8 years, however, they have been able to reconstruct a few bones associated with the birth canal from human ancestors dating as far back as 3 million years. At a symposium at last month's meeting of the American Association of Physical Anthropologists in Denver, researchers used those bones to begin tracing the evolution of human birth.

Those reconstructed bones, however, haven't given birth to a single scenario. In fact, they've produced a pair of decidedly nonidentical twins: Some researchers at the symposium presented new evidence that modern birth developed only very recently in our evolutionary history, while others countered with an intriguing speculation that it developed very early on.

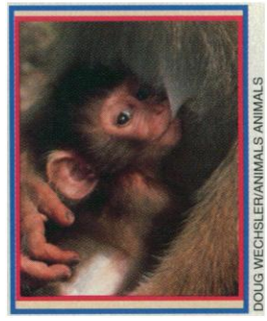
Resolving this "when" question is important, says Wenda Trevathan, an anthropologist at New Mexico State University in Las Cruces, because of the insights it can produce about the social abilities of the creatures who evolved into human beings. "Human birth is so painful and risky," explains Trevathan, whose analysis puts her into the early camp, "that mothers need help from others to deliver a baby successfully." As a result, its development created a powerful selective force for empathy, communication, and cooperation—skills important to being human. And when those traits emerged is another date that anthropologists would love to pin down.

One thing researchers do know is why modern birth gives women such a difficult turn. The human pelvis, which surrounds the birth canal, crimps that canal partway down. At the top, the canal is widest from side to side. The longest dimension of a baby's head is from the nose to the back of the skull, and so the baby enters the canal facing sideways. But lower down, the canal changes its shape so that the longest dimension is from front to back. As a result, the infant must rotate 90 degrees. And there's one more twist: The baby's head is broadest at the back, but the lower canal is a bit broader at the front. So the infant enters the world facing down.

Apes, which have small heads and relatively larger pelves, don't have to go through these gyrations. In 1960, anthropologist Sherwood Washburn of the University of California, Berkeley, speculated that humans took this turn for the worse because the lineage was caught in an "obstetrical dilemma." The pelvis narrowed in response to two-legged walking, since this helps center our legs under our bodies. But as babies' heads and brains started getting bigger, the fit became really tight. The theory seemed sound, but the first hard evidence of when and how the pelvic girdle changed didn't come until 1986.



Proboscis Monkey



Macaque

That was the year Owen Lovejoy of Kent State University in Ohio and Robert Tague, now at Louisiana State University, reconstructed the pelves of two australopithecines (the oldest known nonape human forerunners), including one belonging to "Lucy," the famous 3-million-year-old fossil female. They found that the australopithecine pelvis had changed from an apelike pattern. The back, which supports most of the upper body, had moved closer to the hip joints, giving the pelvis the shape of an oval stretched from hip to hip. The change helped "to adjust posture in a biped," says Tague.

But it also had implications for how australopithecine babies were born. Unlike newborn apes, which can ride into the world facing up all the way, australopithecine babies had to face sideways, Tague and Lovejoy argued. Only then could the head pass through the birth canal.

In Denver, Chris Ruff of the Johns Hopkins University School of Medicine argued that's probably the way hominid babies came into the world until just a few hundred thousand years ago. He based this conclusion on an analysis of two different parts of the skeleton of early *Homo*, human ancestors who appeared at least 2 million years ago, and some of their successors. First, Ruff measured the curve of the iliac brim, a bony feature that forms part of the start of the birth canal, and extrapolated from it the overall shape of the birth canal opening in early *Homo*. He concluded that the canal of this ancestor was oval, much like its shape in australopithecines.

The second feature Ruff examined was related to the width at the lower end of the canal: the shape of the thigh bones just below where some muscles attach them to the side of the pelvis. Bones change shape in response to the force of muscle tugs. And Ruff noted that in nine early *Homo* specimens, ranging in age from 1.9 to 0.7 million years old, the thigh bone shapes indicated these muscles were pulling very hard. "They would only do that if the hip joints were wider apart" than in modern humans, Ruff says. The muscles pull to counterbalance the weight of the airborne hip and leg during a step; the farther away that hip is, the harder they have to pull. The wide pelvis implied by these muscle actions also implies a wide birth canal "broadened to fit the head sideways all the way down," Ruff says. In other words, no rotation.

In fact, he continues, there's no evidence that the lower pelvis changed much from the australopithecine pattern until the last few hundred thousand years, with early modern humans and the Neanderthals. By that time, average brain size had shot up from about 800 milliliters in early *Homo* to more than 1200 milliliters (modern human brains are about 1400 milliliters, though there is a huge range of variation). "The head had become a critical component" in birth, says Ruff. To let it through, the lower end of the bony birth canal had to enlarge. It couldn't get any wider from side to side than it already was, because that would splay the legs out, Ruff says, and so it elongated from front to back. And that change meant that human infants had to spin as they traversed the canal, first facing sideways, then turning so that they emerge face down.

Aware of the fragmentary nature of the fossils that Ruff used, other researchers were reserved in their reactions, although many found the argument plausible. "This is a very creative approach, because there are so few [whole pelves]," says Tague. "And Ruff is always very thorough in his work." One who does disagree is Lovejoy, who, though he did not hear Ruff's talk, says that in general "there's too much slop in the relationship between the [top of the thigh bone] and the birth canal to draw a reliable conclusion."

Another demurral comes from Trevathan, though for different reasons: She thinks rotation may have arisen very early—even in the australopithecines. She pointed out that if australopithecine babies did face sideways as they came through the canal, the next part of their anatomy coming through would cause problems: the shoulders, which would stretch across the narrowest diameter of the oval. "The shoulders are rigid, and they'd get caught," she says. The best way out, Trevathan suggests, was a rotational birth. The anthropologist, who was trained as a midwife, points out that even in modern humans the shoulders are a problem, particularly in larger babies.

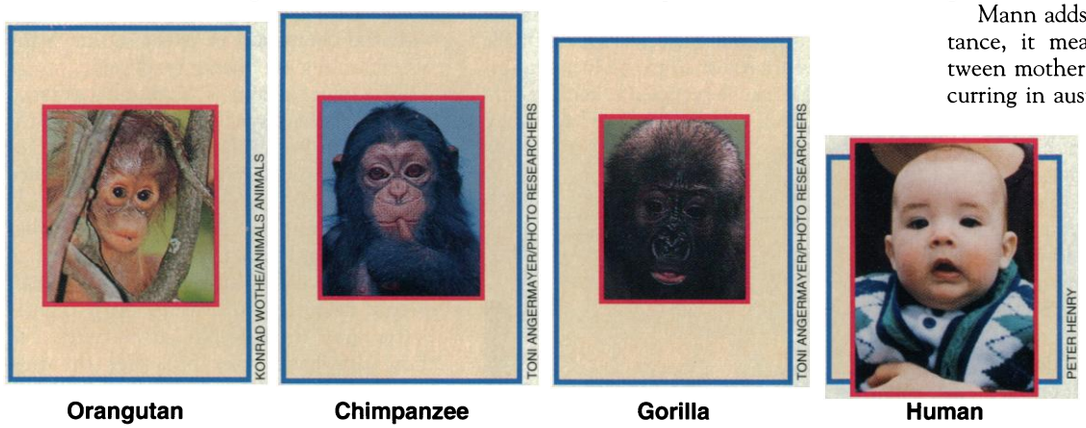
As with Ruff's work, this notion was greeted with caution, but not rejection. Anthropologist Alan Mann of the University of Pennsylvania noted that "Obstetricians have been telling me for years about the great difficulty in fitting the shoulders through," yet anthropologists seem to have left them out of the evolutionary picture. Rosenberg, who likes the idea, says, however, that "I worry a bit that we may be exaggerating the importance of the shoulders. I'm not saying it's wrong, but Wenda only suggested it was a real problem with big babies," and australopithecine babies could have been rather small. And Ruff simply suggests that the babies could have turned their necks, lining their heads up with their shoulders and avoiding the problem altogether.

The time when this rotation entered the picture might seem like a detail, but anthropologists feel that it's a crucial one, because that's when mothers began to need outside help. "Chimps hide at the time of birth; humans do exactly the opposite and seek assistance," Rosenberg says. The pain and difficulty of labor put a premium on companionship, Trevathan contends; studies by Marshall Klaus at Children's Hospital in Oakland, California, have shown that the presence of a support person during labor reduces the rate of Caesarean sections and other birth complications. Since aid at birth increases the chance of reproductive success, traits that support this aid become products of natural selection. Emotional empathy, communication, and responsiveness all fall into this category. "Of course, birth isn't the only pressure for social relationships, but it's got to be an important one," Rosenberg says.

Mann adds that "if a female needs assistance, it means complex interaction between mother and assistant. If this was occurring in australopithecines, it would suggest they are more complicated than the field appears to view them at the moment—something more than simple apes." He has argued that australopithecine babies went through a prolonged period of dependence, and this too would put a premium on social cooperation. "Of course," Rosenberg notes, "if Wenda's idea isn't true, then it means that rotation and cooperation probably didn't arrive until much later."

How, then, can this timing issue be resolved? "I hate to say this, because anthropologists always say it," Rosenberg says, "but we need more fossils. We have two female australopithecines, and I'd like some female early *Homo* pelves as well." There are none at present, preventing scientists from getting a more direct look at the birth canal and all it entails. Researchers are waiting for that chance—expectantly.

–Joshua Fischman



Odd species out. Among the primates, such as the apes and monkeys shown here, the area of the infant's head (represented by the photographs) is usually smaller than the area of the birth canal inlet (outer box). The lone exception: humans, which makes birth a tight squeeze. (Diagram source: A. H. Schultz)