speech defects in humans do not affect those parts of *FOXP2* unique to us. And "some of the changes in humans previously thought unique are seen in other mammals," such as cats, says Stephen Rossiter of Queen Mary, University of London. "As we're looking at more species, we're seeing more differences. The picture is getting complicated."

In September, Rossiter and his colleagues revealed that bats, which use echolocation are an exception to the rule of *FOXP2*'s unchanging nature: the gene varies widely within the group. "There's double the number of changes within bats as compared with all the other vertebrates surveyed," he says. The finding supports the idea that human *FOXP2* is particularly important in the physical control of speech. Like talking, which engages more than 100 muscles, making the sounds needed for sonar requires "massively complex coordination of the face and mouth," Rossiter says.

Bats are one of the few animals that show vocal learning, along with humans, some songbirds, whales and dolphins. That is, the sounds they make are not innate but require practice and imitation. Studies in songbirds support the link between *FOXP2* and vocal learning, suggesting that as well as controlling how our brain forms, the gene might also influence how we use it. The gene changes its activity in the brains of adult birds when they learn and practice their songs, neuroscientist Stephanie White of the University of California, Los Angeles, has found. "Birds may have the same circuitry that formed the foundations for human language," White explains. The evidence points to *FOXP2* being a switch, she says, that different species put to varying uses in their neural machinery.

The gene's story hints at how evolution puts old materials to new uses, points out psychologist Gary Marcus of New York University. "It's a very good entrée into language and how it relates to whatever preadaptations for language we inherited from our ancestors."

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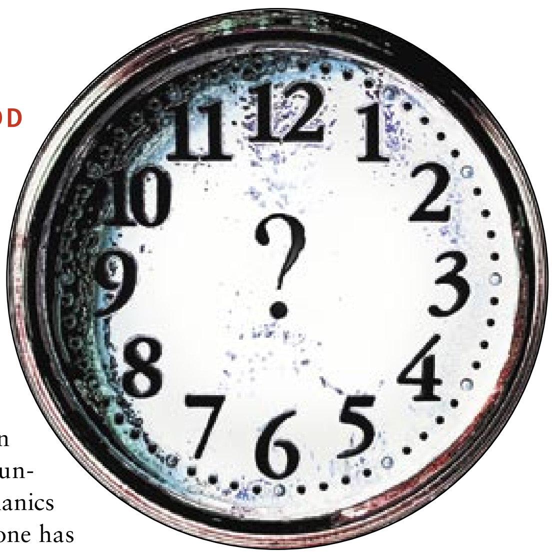
PHYSICS

Making Space for Time

Physicists meet to puzzle out why time flows one way BY SCOTT DODD



"Emoclew dna olleh," Columbia University string theorist Brian Greene said as he opened a conference at the New York Academy of Sciences last October. "If you understood that as 'Hello and welcome' in time reverse," he clarified, "you probably don't need to be here."

No one left. Many of the world's top theoretical physicists and cosmologists gathered at the conference to grapple with the mystery of how time works. New telescope observations and novel thinking about quantum gravity have convinced them that it is time to reexamine time. "We've answered classic questions about time by replacing them with other hard questions," says cosmologist Max Tegmark of the Massachusetts Institute of Technology.

On the face of it, time seems pretty simple, like a one-way street: eggs don't unscramble, laugh lines don't vanish (not without Botox, anyway), and your grandparents will never be younger than you. But the universe's basic laws appear to be time-symmetrical, meaning they are unaffected by the direction of time. From the point of view of physics, the past, present and future exist simultaneously.

For more than a century, physicists have proposed any number of explanations for this apparent contradiction, from the psychological (the flow of time is an illusion) to the physical (some unknown property of quantum mechanics reconciles the contradiction). None has proved satisfactory. In 1927 astrophysicist Sir Arthur Eddington coined the term "time's arrow" for the phenomenon and linked it to entropy: as the universe gets older, it becomes more disordered, following the second law of thermodynamics.

But scientists cannot explain why order lies in the past and disorder in the future. A solution has appeared so elusive that at times it has been regarded as a distraction from more "respectable" research. Physicist Richard Feynman even refused to have comments about time's arrow attributed to him at a conference in 1963, insisting on being identified as "Mr. X."

"The problem is at the borderline between science and philosophy, and a lot of people don't feel comfortable in that area," says Laura Mersini-Houghton, a physicist at the University of North Carolina at Chapel Hill and co-organizer of the conference. "It's been very difficult to make progress over the past 20 years, because there hasn't been much new to say."

That is all changing thanks to stronger instruments for probing the heavens. The cosmic microwave background radiation,

FREDRIK SKOLD *Getty Images*

a remnant of the big bang, shows that 380,000 years after its birth, the universe was filled with hot gas, all evenly distributed and highly ordered. Eventually the early cosmos underwent inflation and began to coalesce into the disordered universe of stars and atoms we know today.

What remains puzzling, though, is why the early universe was so orderly—a condition that physicists consider highly improbable—and what caused it to swell so rapidly. "The arrow-of-time problem, once you get down to the nitty-gritty of it, is, Why was the early universe the way it was?" says Sean Carroll, a cosmologist at the California Institute of Technology. What is more, the cosmos is now going through another period of expansion, with galaxies flying apart at an increasing rate because of a mysterious dark energy. "The fact that it appears that the universe is just going to expand forever and get colder and colder makes [the different conditions] even more striking," Carroll adds.

Mersini-Houghton and her colleagues brought together some of the best minds in the field for the conference because, as she puts it, "we can't just brush this problem under the rug anymore and hope it will be solved by something else." Prominent physicists such as Greene, Tegmark, Lee Smolin of the Perimeter Institute for Theoretical Physics in Ontario, Paul Davies of Arizona State University and Andreas Albrecht of the University of California, Davis, invoked string theory, black hole equations and the idea that we live in one of many parallel universes as possible explanations.

The multiverse concept emerged as one of the more favored—or at least frequently talked about—theories for the strange tidiness of the early cosmos. "If you accept the idea that this might be only one of many possible universes, then that makes it more plausible," Mersini-Houghton says. Universes that started out more chaotic might not have survived or evolved to support intelligent life. So one-way time—and our entire existence, for that matter—could be just a happenstance.

Several attendees said that understanding time is vital to helping them answer other fundamental questions, including what happens at the center of a singularity and whether cosmic inflation could one day reverse, causing the universe to collapse. And the growing cosmological data allow physicists to make predictions about the nature of time and the early universe that could soon be tested through new observations. "We can see a lot more than we could before, and that means we can be a bit more daring," Mersini-Houghton says. It's about time.

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ECOLOGY

Relative Distance

Hyena "wingmen" sacrifice sex for an unrelated male BY DAN EATHERLEY

In many animals, relatives tend to stay close, either sharing the same territory or living in neighboring ones. By sticking together, individuals can defend food, mates and other resources, thereby working to perpetuate the family genes, even if not all manage to breed or raise young.

One particular mammal, however, turns this general observation on its head, and experts in behavioral ecology do not quite understand why. Striped hyenas (*Hyaena hyaena*), which live in Africa and parts of Asia, demonstrate so-called protosocial tendencies. Although little direct interaction occurs among individual hyenas, a closer look reveals that they actually form spatial groups living on exclusive and stable ranges just like species that display obvious social behavior. One would expect relatives to share the same territory or to inhabit territories close together. This is not always so, however, claims Aaron P. Wagner, now at Michigan State University.

Wagner and his colleagues trapped an entire population of striped hyenas in Kenya's Laikipia District, about 135 miles north of Nairobi, and collected its members' DNA. The scientists also radio-tracked the animals to understand their movements. "As far as we are aware, the patterns of relatedness and space use we found in these hyenas are unseen in any other carnivore," says Wagner, who published some of the results of the four-year study in the October 2007 *Molecular Ecology*.

Wagner's team found that the spatial groups formed by this species always consist of just a single female defended by up to three males. Similar coalitions occur in other carnivores, but in those cases the males usually guard several females so that each male has a chance to mate. With only one female available, however, some male striped hyenas are unlikely to breed at all. Such sacrifice and cooperation could be understandable if all males were related, but genetic analysis showed that the hyena coalitions often include unrelated males.

A. P. WAGNER

RANGE ROVERS: Tracking collars revealed that, unlike other mammals that display social behavior, neighboring striped hyenas are often not related.