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The time of his life

April 27 2002

It is a miracle Stephen Hawking is still alive, let alone still plumbing the mysteries of the universe with as much vigour as ever. Gregory Benford caught up with his old friend.

Stephen Hawking seemed slightly worse, as always. It is a miracle that he has clung to life for more than 20 years with Lou Gehrig's disease. Each time I see him I feel that it will be the last, that he cannot hold on to such a thin thread for much longer.



Photo-illustration: Harry Afentoglou

Hawking turned 60 in January. Over the course of his brilliant career, he has worked out many of the basics of black-hole physics, including, most strikingly, his prediction that black holes aren't entirely black. Instead, if they have masses equivalent to a mountain's, they radiate particles of all kinds.

The enormous success of Hawking's 1988 book, *A Brief History of Time*, has made him a curious kind of cultural icon. He wonders how many of the starlets and rock stars who mentioned the book on talk shows actually read it.

With his latest book, *The Universe in a Nutshell*, he aims to remedy the situation with a plethora of friendly illustrations to help readers decipher such complex topics as superstring theory and the nature of time. The trick is translating equations into sentences, no mean feat. The pictures help enormously, though purists deplore them as oversimplified. I feel that any device is justified to span such an abyss of incomprehension.

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At Hawking's office at the University of Cambridge, his staff were wary of me, plainly suspecting I was a "civilian" harbouring a crank theory of the universe. But I'd called beforehand, and then his secretary recognised me from years past. (I am an astrophysicist and have known Hawking since the 1970s.) When I entered the familiar office his shrunken form lolled in his motorised chair as he stared out, rendered goggle-eyed by his thick glasses - but a strong spirit animated all he said.

Hawking lost his vocal cords years ago, to an emergency tracheotomy. His gnarled, feeble hands could not hold a pen. For a while after the operation he was completely cut off from the world, an unsettling parallel to those mathematical observers who plunge into black holes, their signals to the outside receding and slowed by gravity's grip to dim, whispering oblivion.

A Silicon Valley firm came to the rescue. Engineers devised tailored, user-friendly software and a special keyboard for Hawking. Now his frail hand moved across it with crab-like speed. The software is deft, and he can build sentences quickly. I watched him flit through the menu of often-used words on his liquid crystal display, which hung before him in his wheelchair. The invention has been such a success that the Silicon Valley folk now supply units to similarly afflicted people worldwide.

"Please excuse my American accent," the speaker mounted behind the wheelchair said with a California inflection. He coded this entire remark with two keystrokes.

Although I had been here before, I was again struck that a man who had suffered such an agonising physical decline had on his walls several large posters of a person very nearly his opposite: Marilyn Monroe. I mentioned her, and Hawking responded instantly, tapping one-handed on his keyboard, so that soon his transduced voice replied, "Yes, she's wonderful. Cosmological. I wanted to put a picture of her in my latest book, as a celestial object." I remarked that to me the book was like a French impressionist painting of a cow, meant to give a glancing essence, not the real, smelly animal. Few would care to savour the details. Hawking took off from this to discuss some ideas currently booting around the physics community about the origin of the universe, the moment just after the Big Bang.

Hawking's great politeness paradoxically made me ill at ease; I was acutely aware of the many demands on his time, and, after all, I had just stopped by to talk shop.

"For years my early work with Roger Penrose seemed to be a disaster for science," Hawking said. "It showed that the universe must have begun with a singularity [a moment when matter is infinitely dense], if Einstein's general theory of relativity is correct. That appeared to indicate that science could not predict how the universe would begin. The laws would break down at the point of infinite density." Mathematics cannot handle physical quantities like density that literally go to infinity. Indeed, the history of 20th-century physics was in large measure about how to avoid the infinities that crop up in cosmology. I recalled that I had

spoken to Hawking about mathematical methods of getting around this problem one evening at a party in King's College. "It now appears that the way the universe began can indeed be determined, using imaginary time," Hawking said. We discussed this a bit. He had been using a mathematical device in which time is replaced by something called imaginary time. This changes the nature of the equations; in the new equations, a kind of tunnelling occurs in which the universe, before the Big Bang, has many different ways to pass through the singularity. With imaginary time, one can calculate the chances for a given tunnelling path into our early universe after the beginning of time as we know it.

"Sure, the equations can be interpreted that way," I argued, "but it's really a trick, isn't it?"

Hawking said, "Yes, but perhaps an insightful trick."

"We don't have a truly deep understanding of time," I replied, "so replacing real time with imaginary time doesn't mean much to us."

"Imaginary time is a new dimension, at right angles to ordinary, real time," Hawking explained.

I shrugged in exasperation at the span between cool mathematical spaces and the immediacy of the raw world; this is a common tension in doing physics. "It's unrelated to how we feel time. The seconds sliding by. Birth and death," I add.

"True. Our minds work in real time, which begins at the Big Bang and will end, if there is a Big Crunch - which seems unlikely, now, from the latest data showing accelerating expansion. Consciousness would come to an end at a singularity."

"Not a great consolation," I said. "Remember what you predicted in 1980 about final theories like this?" I chided him.

"I suggested we might find a complete unified theory by the end of the century." Hawking made the transponder laugh dryly. "OK, I was wrong. I was a bit optimistic but I still think there's a 50-50 chance that we will find a complete unified theory in the next 20 years.

"It is possible that there is no ultimate theory of physics at all. Instead, we will keep on discovering new layers of structure. But it seems that physics gets simpler, and more unified, the smaller the scale on which we look. So I think there will be some ultimate theory, which we will discover if we are smart enough."

"Does it seem likely that we are smart enough?" I asked.

Another grin. "You will have to get your faith elsewhere."

We began discussing recent work on "baby universes" - bubbles in space-time. To us large creatures, space-time is like the sea seen from an ocean liner, smooth and serene.

Up close, though, on tiny scales, it's waves and bubbles. Sometimes, rarely but inevitably, these bubbles could grow into a full-fledged universe.

This might have happened a lot at the instant just immediately after the Big Bang. Indeed, some properties of our universe may have been created by the space-time foam that roiled through those infinitesimally split seconds. It turns out that such bubbles could even form right now. An entirely separate space-time could pop into existence in your living room, say. It would start unimaginably small, then balloon to the size of a rockmelon - but not before your very eyes, because, for quite fundamental reasons, you couldn't see it.

"They don't form in space, of course," Hawking said. "It doesn't mean anything to ask where in space these things occur." They don't take up room in our universe but rather are their own universes, expanding into spaces that did not exist before.

"They're cut off from us after we make them," I said. "No relics, no fossil?"

"I do not think there could be."

"So they form and go," I mused. "Vanish. Between us and these other universes lies absolute nothingness, in the exact sense - no space or time, no matter, no energy."

"There can be no way to reach them," his flat voice replied. "The gulf between us and them is unbridgeable. It is beyond physics because it is truly nothing, not physical at all."

The mechanical laugh resounded. Hawking likes the tug of the philosophical, and he seemed amused by the notion that universes are simply one of those things that happen from time to time.

His nurse appeared for a bit of physical clean-up, and I left him. Inert confinement to a wheelchair exacts a demeaning toll on one's dignity, but he showed no reaction to the daily round of being cared for by another in the most intimate way. Perhaps for him, it even helps the mind to slip free of the world's rub.

I sat in the common room outside his office, having tea and talking to some of his postdoctoral students. They were working on similarly wild ideas and were quick, witty, and keenly observant as they sipped their strong, dark Ceylonese tea. A sharp crew, perhaps a bit jealous of Hawking's time.

His secretary quietly came out and asked if I would join Hawking for dinner at Caius College. I had intended to eat in my favorite Indian restaurant, where the chicken vindaloo is a purging experience, and then simply rove the walks of Cambridge alone, because I love the atmosphere - but I instantly assented. Dinner at college high table is one of the legendary experiences of England. I could remember keenly each one I had attended; the repartee is sharper

than the cutlery.

We made our way through the cool, atmospheric turns of the colleges, the worn wood and grey stones reflecting voices and squeaks of rusty bicycles. In misty twilight, student shouts echoing, Hawking's wheelchair jouncing over cobbled streets. He insisted on steering it himself, though his nurse hovered rather nervously. It had never occurred to me just how much of a strain on everyone there can be in round-the-clock care. A few people drifted along behind us, just watching him. "Take no notice," his mechanical voice said. "Many of them come here just to stare at me."

We wound among the ancient stone and manicured gardens, into Caius College. Students entering the dining hall made an eager rumpus. Hawking took the elevator, and I ascended the creaking stairs. The faculty entered after the students, me following with the nurse.

The high table is literally so. They carefully placed Hawking with his back to the long, broad tables of undergraduates. I soon realised that this is because watching him eat, with virtually no lip control, is not appetising. He follows a set diet that requires no chewing. His nurse must chop up his food and spoon-feed him.

The dinner was noisy, with the year's new undergraduates staring at the famous Hawking's back. He carried on a matter-of-fact, steady flow of conversation through his keyboard.

He had concerns about the physicists' Holy Grail, a unified theory of everything. Even if we could thrash our way through a thicket of mathematics to glimpse its outlines, it might not be specific enough - that is, we would still have a range of choices. Here is where aesthetics might enter.

"If such a theory is not unique," he said, "one would have to appeal to some outside principle, which one might call God."

I frowned. "Not as the Creator, but as a referee?"

"He would decide which theory was more than just a set of equations, but described a universe that actually exists."

"This one," I said.

"Or maybe all possible theories describe universes that exist!" he said with glee.

After dinner, high table moved to the senior common room upstairs. We relaxed along a long, polished table in comfortable padded chairs, enjoying the traditional crisp walnuts and ancient aromatic port, Cuban cigars, and arch conversation, occasionally skewered by a witty interjection from Hawking.

Someone mentioned American physicist Steven Weinberg's statement, in *The First Three Minutes*, that the more we comprehend the universe, the more meaningless it seems.

Hawking doesn't agree, and neither do I, but he has a better reason. "I think it is not meaningful in the first place to say that the universe is pointless, or that it is designed for some purpose."

I asked, "No meaning, then, to the pursuit of meaning?"

"To do that would require one to stand outside the universe, which is not possible," he said.

Again the image of the gulf between the observer and the object of study. "Still," I persisted, "there is amazing structure we can see from inside."

Hawking: "The overwhelming impression is of order. The more we discover about the universe, the more we find that it is governed by rational laws. If one liked, one could say that this order was the work of God. Einstein thought so."

One of the college fellows asked, "Rational faith?"

Hawking tapped quickly. "We shouldn't be surprised that conditions in the universe are suitable for life, but this is not evidence that the universe was designed to allow for life. We could call order by the name of God, but it would be an impersonal God. There's not much personal about the laws of physics."

Walnuts eaten, port drunk, cigars smoked, it was time to go. When we left, Hawking guided his wheelchair through the shadowy reaches of the college, indulging my curiosity about a time-honoured undergraduate sport: climbing Cambridge.

At night, young men sometimes scramble among the upper reaches of the steeped old buildings, scaling the most difficult points. They risk their necks for the glory of it. Quite out of bounds, of course. Part of the thrill is eluding the proctors who scan the rooftops late at night, listening for the scrape of heels. There is even a booklet about roof climbing, describing its triumphs and centuries-long history.

Hawking took me to a passageway I had been through many times, a short cut to the Cam River between high, peaked buildings of undergraduate rooms. He said that it was one of the tough events, jumping across that and then scaling a steep, often slick roof beyond.

The passage looked to be about three metres across. I couldn't imagine leaping that gap from the slate-dark roofs. And at night, too. "All that distance?" I asked. My voice echoed in the fog.

"Yes," he said.

"Anybody ever miss?"

"Yes."

"Injured?"

"Yes."

"Killed?"

His eyes twinkled and he gave us a broad smile. "Yes."

A week after my evening at Cambridge, I got from Hawking's secretary a transcript of all his remarks. I have used it here to reproduce his style of conversation. Printed out on his wheelchair computer, his sole link with us, the lines seem to come from a great distance. Across an abyss.

I had learned a good deal from those few hours, I realised, and most of it was not at all about cosmology.

Gregory Benford is a professor of physics at the University of California, Irvine. His most recent non-fiction book is *Deep Time* (Avon).

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