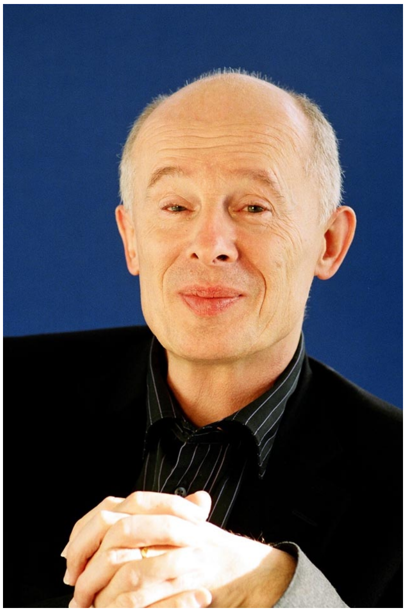
Profile of Hans Joachim Schellnhuber

How Hans Joachim ("John") Schellnhuber became one of the world's leading experts in climate change is somewhat ironic. As a postdoctoral fellow at the Institute of Theoretical Physics (ITP) at the University of California, Santa Barbara, he worked in an area famous for its eternal summer. Unlike most places on the continent, which swing from icy winters to sweltering summers, the southern California city is known for its near-perfect, virtually unchanging climate. At Santa Barbara, he chose to pursue research in chaos theory, a decision that set him on the path to his current posts as scientific advisor to the German chancellor and director of the Potsdam Institute for Climate Impact Research (PIK, Potsdam, Germany).

The pressure Schellnhuber put on himself to succeed armored him against Santa Barbara's seductions, however. At the ITP, he pored over his calculations, trying to keep pace with five current and future Nobel laureates, whose offices were just across the hall. He recalls this period with a hint of regret. "There was no time for going to the beach and windsurfing," he says. "On the one hand, it's a lovely landscape. On the other hand, if you do theoretical physics, you cannot take much notice. Sometimes it's better if you live in a dreary place." He insists that his current campus in Potsdam is "stunning and beautiful and full of reminiscences of great minds" like Einstein. Still, it has no palm trees.

Schellnhuber has a Ph.D. in theoretical physics from the University of Regensburg (Regensburg, Germany) and has done fundamental work on quantum mechanics and nonlinear dynamics, yet he has also served as professor and director of the Institute for Chemistry and Biology of the Marine Environment (ICBM) at the University of Oldenburg, Germany, which focuses on tidal flat research. His scientific background has prepared him for overseeing the interdisciplinary projects crucial in climate change, which he calls "the biggest challenge of the 21st century." From 2002 to 2005, he was director of the United Kingdom's Tyndall Centre for Climate Change Research in East Anglia (Norwich, U.K.). In recognition of this service, he was made a Commander of the Order of the British Empire. Schellnhuber was named a foreign associate of the National Academy of Sciences in 2005.



Hans Joachim "John" Schellnhuber

Lazy Days

Schellnhuber was born in 1950 in Ortenburg, West Germany. As a young boy, he acquired the nickname "John," which served him much better than "Hans Joachim" during his time in the United States and United Kingdom. Today, everyone calls him John, including his colleagues, his mother, and his wife.

He recalls that, from childhood, everything came easily to him in school. "I was a fairly lazy boy," he says. He achieved top regional marks in the Abitur, the set of exams marking graduation from secondary school, which won him a university scholarship for the exceptionally gifted. His next test was choosing a specialty. "I simply felt the combination of physics and mathematics was the most challenging," he says, "and so I went for that. But I could just as well have done sociology or economics."

Young West Germans in the 1950s were not free to move about the country. Despite his stellar academic record, Schellnhuber did not apply to prestigious universities such as Goettingen or Heidelberg, as an American might apply to Ivy League schools. He chose to attend the University of Regensburg, not far from his parents and hometown. "It was okay," he says. "It was not an exceptional university. I could more or less do what I liked and I had very good teachers. My professors in mathematics were superb. It was a young university at that time and I felt happy with that." He completed his Ph.D. in theoretical physics in 1980. His dissertation was on the band structure (the range of possible energies) of crystal electrons in magnetic fields. In his dissertation, he validated the Peierls–Onsager Hypothesis, which had baffled physicists for decades (1).

Time for Change

Having spent a decade at the University of Regensburg, Schellnhuber felt it was time for a change. Gregory Wannier, a physicist known for the Wannier functions essential to solid state physics, visited his Ph.D. supervisor, Schellnhuber recalls. Once he learned of Schellnhuber's work, Wannier was impressed and recommended the young scientist for promotion and for travel to the United States for further studies. Wannier wrote on Schellnhuber's behalf to Walter Kohn, the director of the ITP at Santa Barbara. Kohn, who would win the Nobel Prize for Chemistry in 1998, was recruiting worldwide for his institute.

So in 1981, Schellnhuber, not yet fluent in English, found himself across the corridor from Kohn, as well as John Bardeen and John Schrieffer (who, along with Leon Cooper, coined the "BCS" theory of superconductivity) and two other Nobel laureates, ignoring the sun and surf. The most substantial advance he made with his colleagues during this stint was solving quantum mechanics' Schroedinger equation for the Fibonacci Hamiltonian: a particle in an almost-periodic potential well. Their results were published in *Physical Review Letters* (2). "You find very peculiar band structures," Schellnhuber says, "It's a very weird thing." But this weird thing, it later turned out, corresponded to two-dimensional quasicrystals, which form under specific conditions and can be seen as "Penrose tiling" when pentagons cover a surface.

In 1984, Schellnhuber returned to West Germany. By this time, he had moved away from condensed matter physics and, after being introduced to nonlinear dynamics—or chaos theory—by Benoît Mandelbrot and Mitch Feigenbaum at ITP, was working exclusively in complex systems analysis. The University of Oldenburg offered him a tenure-track position, but before he could be certified as a full professor, he had to complete a "Habilitation," a postdoctoral degree required by several European countries. "It's a very obsolete thing," he says. "I wasted some time on that, I wrote some papers. . . "

This is a Profile of a recently elected member of the National Academy of Sciences to accompany the member's Inaugural Article on page 1786.

However, the work he did for the Habilitation, which he received in 1985, won him a Heisenberg fellowship: a five-year award that came with a professorial salary and few strings attached. Over the course of the fellowship, he visited the University of California, Santa Cruz to work with Michael Nauenberg, who had been deputy director of the ITP and whose research on nonlinear dynamics was well known. Schellnhuber also spent time at the University of California, Berkeley and the mathematics department at Warwick University (Coventry, UK) before returning to Oldenburg and building his own research group.

Tidal Flat Theories

In 1989, Schellnhuber became a full professor and, shortly thereafter, director at Oldenburg's ICBM. The institute is on the north coast of Germany and specializes in tidal flat research. Tidal flats are "very peculiar ecosystems," he says. "[They are] a sort of fractal structure. It's interesting how the water is transported and how nutrients are transported through these fractal structures, how algae start to settle there." Researchers from geology, biology, and chemistry came to ask him for advice about how to construct a mathematical model for their specialties. "So I started to become interested in ecosystems," he says, "not because I was a green activist, it was simply through sheer scientific curiosity."

His own group focused on the stability of nonperiodic orbits, using Kolmogorov–Arnold–Moser theory. "That is probably the most complicated mathematical issue you can do in nonlinear dynamics," he says. Meanwhile, his colleagues in the institute were considering how algae grew in the mud. "I found it refreshing." he says. "You cannot do 12 hours a day thinking of Kolmogorov–Arnold–Moser theory. There may be some people doing that but, in general, you do it a few hours a day. I found it more enjoyable to talk to people and even go out to the tidal flats to look at the structures."

In the early 1990s, debate heated up about the human contribution to global warming. The West German Ministry for Science and Technology was looking for scientists who could help predict the effects of climate change on the coastline. "For example, if the sea level rises, what is the impact on the tidal flats?" Schellnhuber remembers. "That's an interesting theoretical problem because the tidal flats are fractally organized. What will happen to the overall morphology? What will happen to the ecological cycles? It is really complex." He agreed to be coordinator of the entire project. "I did not feel that the end of the world was coming. I just found it an interesting and curious problem."

Nonlinear Events

"Then something highly nonlinear happened," he says. "The Berlin Wall came down." As part of German reunification, the West German Academy of Sciences was "dismantled" and reincorporated in Potsdam, at the famous campus where the physicists Michelson and Schwarzfeld had conducted their experiments and on which sits the quirky Einstein Tower, an observatory built to verify the predictions of general relativity.

"They [the German government] wanted to build an institute for climate impact research," Schellnhuber says. He agreed, beginning what is now known as the PIK. "They asked me, because I had coordinated the ICBM program, if I would be the founding director." Although he admitted that he did not know the field very well, he agreed because he loves a challenge and he could feel the spirit of genius on the campus.

> "The dangerous impacts of climate change can only be discussed in terms of nonlinear behavior."

Schellnhuber is also listed as a professor of theoretical physics at the University of Potsdam, but his main job is as director of PIK. "It was the first institute in the world," he says, "which tried to do a full interdisciplinary analysis of global warming: What will the impact be, what are the dynamics, the tipping points, what are the economic costs and benefits of climate protection. We built a group to do macroeconomic modeling. And PIK has flourished ever since."

Advice at the Highest Level

PIK's primary mandate is "to do good research," he says. "But the second thing is that we should also inform the public about these issues and provide advice to decision-makers." Schellnhuber is well-placed to do just that. He officially advises Angela Merkel, the German chancellor, on climate change. In addition, because Germany currently holds the twin presidencies of the European Union and the G8, Schellnhuber helped prepare the agenda for the May 2007 G8 summit in Heiligendam, Germany.

From 2002 to 2005, Schellnhuber was allocated from PIK to serve as the research director at the Tyndall Centre for Climate Change Research at Norwich. Via Oxford's Tyndall Centre, he became affiliated with the Oxford University Physics Department and the Environmental Change Institute. "I soon became acquainted with Sir David King, who is the U.K. chief scientist," Schellnhuber says, "and he asked me for advice. I also prepared a conference for Tony Blair for the 2005 G8 summit in Gleneagles."

When he returned to Germany in 2005, the country's officials soon approached him for scientific advice. "But I was very snobbish, I have to confess," he says. "I said, 'I'm not interested in giving advice to secretaries of state; I would only do it for the federal chancellor!' And I got my way." But this was not the first time he had worked with Merkel, who also holds a Ph.D. in theoretical physics. He had previously advised her when she was the environment minister between 1994 and 1998.

"She's a very bright lady. I see her once a month. And sometimes she just invites me to come to the Chancellery to discuss some things with her. I have always enjoyed debates with her because she is extremely quick to understand complex matters. Over time I have become acquainted with many politicians. Most of them always know everything beforehand. They don't think that a nerd like a theoretical physicist can tell them anything new. While the German chancellor, she's really outstanding, she asks questions until she understands the issue, and then she never forgets. Because she's a physicist and I'm a physicist, we get along extremely well."

He currently serves, for example, on an advisory group for European Commission President José Manuel Barroso. Climate change is a complex phenomenon, but Schellnhuber must still deliver his message. "We always walk a thin line," he says. "There is a saying, 'to every complex question, there is a simple answer, and it is wrong!' But as the French poet Paul Valery said, 'To every complex question, there is a complex answer, and it is useless.' So you have to find a reasonable path between the two extremes."

His background serves him well here. "Physicists have a pictorial understanding of very complex relationships," Schellnhuber says. "Of course, you always need to do it in tongue-in-cheek. You never believe it's a true picture." Werner Heisenberg, he says, always looked for a good picture or analogy, as did Richard Feynman, who invented "a sort of pictorial calculus." Even with an apt analogy in hand, Schellnhuber admits that with many leaders, "you cannot give a scientific lecture. But you try to do it in terms that can be felt intuitively, perceived by people. Sometimes you succeed and sometimes you fail."

Tipping Elements

After many successful, and some failed, attempts to explain climate change to political leaders and CEOs, Schellnhuber has a good sense of what works and what does not. As the lead author of the chapter on "large-scale discontinuities" in the third report produced by the Intergovernmental Panel on Climate Change, he used the phrase "tipping point," which has wide currency in the business world. "In a conversation with a BBC journalist, I said 'these are, more or less, tipping points' [in climate change]," Schellnhuber says. "He immediately understood." Schellnhuber capitalizes on this expression in his Inaugural Article, titled *Tipping elements in the Earth's climate system* (3).

"The dangerous impacts of climate change," he explains, "can only be discussed in terms of nonlinear behavior. If global warming just had gradual impacts—over time everything changed more or less linearly, so you have a little bit less wheat production but you have a little bit more pineapple production—who cares? We could easily adapt to that. But looking back into the past geology of the earth and past climate changes, there were a number of really often abrupt and mostly irreversible changes. Things get changed over thousands of years, and you cannot turn them easily back. Those are what I call 'tipping events.'"

In his Inaugural Article, Schellnhuber and colleagues present a short list of "tipping elements." The systems they describe are at least subcontinental in scale and essentially nonlinear, such as the Indian monsoon and the El Niño–Southern Oscillation, and contain points beyond which positive feedback will cause runaway change that cannot be reversed for a very long time. Schellnhuber and his colleagues chose to consider "policy-relevant" tipping elements, providing examples where the researchers suggest that human activity is causing the change and something can be done about it; the change will occur on a timescale that humans understand, such as a century; and people care about the system because it is economically or biologically important.

"The Brazilian government might be interested to learn whether the Amazon rainforest is about to collapse in the next two or three decades, and what do they have to do in order to reverse that," he says. "We found that the nearest tipping element or tipping point is the Greenland Ice Sheet. If it melts down, there will be a 7-m sea level rise. Of course, this will happen over many centuries, but that will completely change our world. And probably a global warming of another 2 degrees [Celsius] would be sufficient to bring that melting about."

Keeping Credible

After his experience in the United Kingdom, Germany, and the United States, including several visits to Capitol Hill, Schellnhuber has faith that at least some leaders want to hear the truth. "I'm convinced that you simply have to provide the scientific evidence. If politicians ask 'What is going on?' they will turn to the best scientific institutions and not to those who are shouting the loudest. So it's very important that you remain credible."

The belief that his work is important and that his advice will be heeded by people in a position to implement change is what keeps Schellnhuber motivated. In the past year, his whirlwind efforts have prevented him from doing any research of his own, even though he would dearly like to. "As long as you feel you are doing good work, you can work very hard," he says. "But at the very moment you feel you are doing something you do not really want to do, or you don't get noticed by people who should know about your research, or if your advice is completely thrown to the winds, immediately you see it as an unbearable burden. It's the positive feedback that keeps you going."

Kaspar Mossman, *Science Writer*

1. Schellnhuber HJ, Obermair GM (1980) First-principles calculation of diamagnetic band structure. *Phys Rev Lett* 45:276–279.
2. Ostlund S, Pandit R, Rand D, Schellnhuber HJ, Siggia ED (1983) One-dimensional Schrödinger equation with an almost periodic potential. *Phys Rev Lett* 50:1873–1876.
3. Lenton TM, *et al.* (2008) Tipping elements in the Earth's climate system. *Proc Natl Acad Sci USA* 105:1786–1793.