autistic) child has the strong need to be accepted by the peer group, to fit in and to belong. The case of autism starkly reminds us what happens when the normal brain circuits for social development malfunction, and how this affects not just the child's accent, but also their assimilation into culture. □

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A singularity in modern science

Geons, Black Holes, and Quantum Foam: A Life in Physics
by John Archibald Wheeler with Kenneth Ford
W. W. Norton: 1998. 380 pp. $27.95, £19.95

Peter Galison

In the twentieth century theatre of physics, John Wheeler has stood at centre stage but always just out of the spotlight. He worked with Niels Bohr on the theory of nuclear fission in 1939 and on the Manhattan Project during the Second World War, and launched Richard Feynman on the quest that led him to quantum electrodynamics. Alongside Edward Teller, Wheeler helped to make thermonuclear weapons a reality in the late 1940s and early 1950s. From black holes to quantum measurement, from positronium to the collective model of the nucleus, Wheeler transformed an astonishing range of physics.

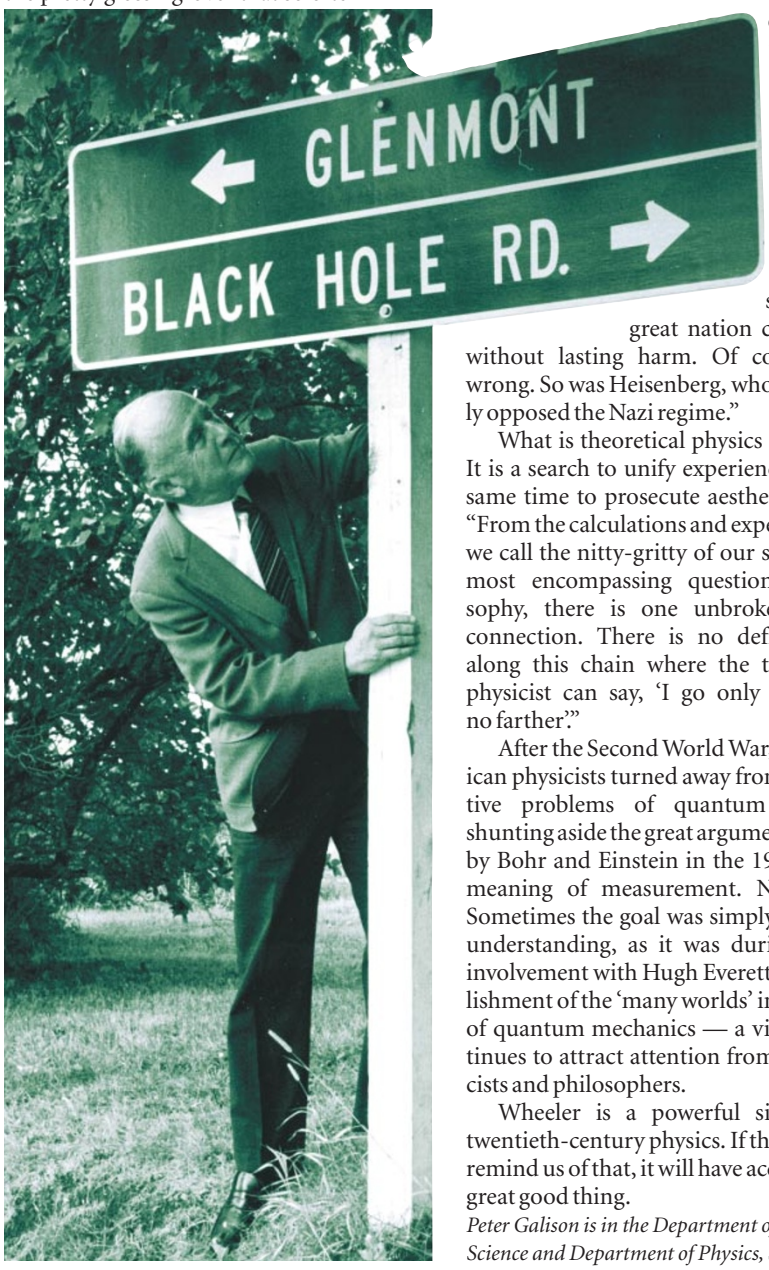
In a sadly conformist age, as herds of theorists thunder to one rumoured oasis after another, Wheeler has somehow maintained a quirky, intuitive, insightful style that is truly his own. There simply has been no one like him — he is and has always been a pragmatic visionary.

Pragmatic: Wheeler grew up an American boy who liked inventions and explosives. He was a theorist who, more than most of the other physicists at the wartime Metallurgical Lab in Chicago, ended up working well and learning easily from the DuPont engineers. Visionary: Bohr's institute in Copenhagen was about as far from American physics as it could be — a place where Bohr and his young associates agonized for days over getting the words, the physics and the philosophy right all at once. What comes through in *Geons, Black Holes, and Quantum Foam* is just how thoroughly, how improbably, how importantly Wheeler joined these American and European impulses.

Wheeler liked to work at the extremes. Could physics be done without fields — a world of particles alone? That became a long-standing project. But even that wasn't extreme enough. So Wheeler called up Feynman one day in 1940 or 1941, and said (more or less), "Feynman, I know why all electrons and all positrons have the same charge." Why? "Because there's only one electron and it travels back and forth in time." In Feynman's hands this idea became a foundation of quantum electrodynamics in 1947–49. When the 'no fields' campaign faltered, Wheeler reversed course and fought on the opposite front, to reduce physics to fields without particles. When Wheeler wanted to explore the limits of gravitational physics, he took Robert Oppenheimer's 1939 speculations about black holes and pushed farther, doing physics at the extremity of the then quiescent field of general relativity.

Kenneth Ford has kept Wheeler's voice. It is a voice of striking honesty. There is none of the pretty glossing-over that so often characterizes retrospective accounts of the Cold War, no pretending that everyone was on wonderful terms, that issues of national security were sidebars to the 'real world' of physics. No, Wheeler remembers Oppenheimer as a concatenation of brilliance and unstraightforward show-off. "My feelings toward him remain as they were more than 60 years ago," he says. "Oppenheimer was a complex human being. I never felt really close to him. I always felt I had to keep my guard up."

He speaks warmly of Teller, yet does not hesitate to criticize him. Nor does Wheeler ignore his own failings, such as his attachment to an idealized picture of Germany that may have delayed the launch of Los Alamos — without that delay, he believes, his brother might not have died on the battlefield. Wheeler says: "I was inclined to believe [as Werner Heisenberg did] that an immoral dictatorship was a transitory evil, something a great nation could endure without lasting harm. Of course, I was wrong. So was Heisenberg, who never openly opposed the Nazi regime."



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Where next? Wheeler has stood at the crossroads of physics and explored diverse directions.

What is theoretical physics for Wheeler? It is a search to unify experience and at the same time to prosecute aesthetic concerns. "From the calculations and experiments that we call the nitty-gritty of our science to the most encompassing questions of philosophy, there is one unbroken chain of connection. There is no definable point along this chain where the truly curious physicist can say, 'I go only this far and no farther'."

After the Second World War, most American physicists turned away from interpretative problems of quantum mechanics, shunting aside the great arguments launched by Bohr and Einstein in the 1930s over the meaning of measurement. Not Wheeler. Sometimes the goal was simply to augment understanding, as it was during his early involvement with Hugh Everett in the establishment of the 'many worlds' interpretation of quantum mechanics — a view that continues to attract attention from both physicists and philosophers.

Wheeler is a powerful singularity in twentieth-century physics. If this book helps remind us of that, it will have accomplished a great good thing. □

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