factors downstream of Snf1p have already been defined by genetic screens (see, for instance, ref. 7). Another aspect of the phenotype of *snf1*-disrupted strains is that they fail to arrest at START in G1 phase when they run out of glucose[8]. This implies that Snf1p (and conceivably AMPK) inhibits progress through the cell cycle, as well as biosynthesis, in response to stress. Another possible connection is that the protein kinase most closely related to Snf1p in the fission yeast *Schizosaccharomyces pombe* is Cdr1/Nim1, although the carboxy-terminal domains are unrelated. Cdr1/Nim1 regulates the cell cycle in response to nitrogen starvation, apparently by phosphorylating the Wee-l protein kinase[9,10].

On the other hand, the signal that switches the system on, and the mechanism by which the signal acts, is well understood in the mammalian system but unknown in yeast. Although changes in adenine nucleotide levels do occur when yeast is starved for glucose, AMP does not appear to activate Snf1p. Nevertheless, it could be that some other small molecule acts as a starvation signal in yeast through a similar mechanism, and phosphorylation of the synthetic peptide now provides a biochemical assay to identify this putative signal molecule. □

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OBITUARY

Julian Schwinger (1918–94)

I FIRST met Julian Schwinger in 1943 at the Massachusetts Institute of Technology. After bouncing back and forth a few times between Cambridge and Chicago, Schwinger had chosen — for his own reasons — to work on radar at the wartime MIT Radiation Laboratory and not, as he had been urged to do, on atomic weapon development in the Manhattan Project. Barely 25, he was already a legendary figure; I, two years younger, was an MIT graduate student about to submit my dissertation. Julian was half-a-dozen years away from his monumental work on quantum electrodynamics (the interaction between electrons and photons) which would bring him the Nobel Prize in Physics in 1965, a prize he shared with Feynman and Tomonaga.

Although Schwinger was world-famous and well travelled, he was quite unworldly. Bold and sure-handed in his physics, he was reserved to the point of shyness in ordinary daily life. He taught me much about physics; I like to think I taught him a little about getting along in the world. We became lifelong friends. Fifty-one years later he developed pancreatic cancer and his life precipitously ended, at the age of 76, on 16 July 1994. He continued working to the end.

Born in New York City, with absolutely no science in his background, he became committed to physics at an unusually early age. He once remarked that he had been reading straight through the *Encyclopaedia Britannica* and when he came to the letter P and to physics, that was it. Largely self-educated, he published his first paper at the age of 17, while an undergraduate student at City College of New York which he had entered the year before. His precocity caught the attention of I. I. Rabi (a future Nobel laureate), who brought him to Columbia University where he published his second paper, also minor, later that year. His first solo publication, on the quantum theory of the scattering of neutrons by magnetic materials, was another matter entirely. Submitted to the *Physical Review* on 11 January 1937, when he was still 18, it was an important piece of work, mature and elegant. The Schwinger techniques, his characteristic mastery of the subject and his physical insight, were on full display for the first time. He was, it was clear, a prodigy.

His progress in those early years was rapid and his contributions major, first to nuclear physics at Columbia and Berkeley, and then to radar at MIT.

After the war, Schwinger joined the faculty at Harvard and became a full professor at 29. Between 1948 and 1950 came the contributions that led to his Nobel Prize. His Lorentz and gauge-invariant reformulation of quantum field theory provided a new and self-consistent basis for renormalizing the formally ill-defined mass and charge of the electron. Contrary to what many believed, no new hypotheses were required, but only the ability to see and work through the extraordinary complexities and apparent contradictions inherent in the conjunction of special relativity and quantum mechanics. His work and Feynman's, over the next decade, revolutionized the quantum theory of fields and of elementary particles and laid the foundation for much of the subsequent spectacular progress in high-energy physics and the ultimate structure of matter. In 1972 he left Harvard to come to the University of California at Los Angeles, where he had the title of University Professor.

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N. Shindler

Schwinger — Nobel prizewinner with Feynman and Tomonaga.

Julian Schwinger's legacy goes far beyond his published work. His lectures were elegant, lucid and original (he never did anything the same way twice), works of art and physics both. During the war years, I was asked to write up his lectures on radar waveguides, work we published as a monograph after the war, and so was a direct and happy beneficiary of his extraordinary qualities as a lecturer. Over the years, many others have similarly benefited from his lectures on such subjects as nuclear physics, quantum mechanics and field theory.

Even more important was his role as a mentor. He directed more than 70 doctoral theses, and his students (and their students) fill the faculties of America's best universities. Of Julian's students, three have also won the Nobel Prize: B. Mottelson and S. Glashow in physics, and W. Gilbert in biology. Schwinger gave his students much more than guidance on their research. He gave them a depth of understanding and a mastery of the field which permitted each to become not a Schwinger disciple, but an independent scientist. Through his students, he has had a more widespread and profound influence on theoretical physics over the past forty years than any other physicist.

Julian was a gentle and cultivated man. He and I had in common a serious love of music. I learned, mainly because of him, to play the recorder; he took piano lessons for decades. "If something is worth doing, it is worth doing badly", he once said of his playing.

There was a bitter-sweet quality to the later part of his life, for theoretical physics changed directions. It became, in Schwinger's view, too speculative, inadequately linked to experiment. He, accustomed to leading, chose not to follow. He became increasingly isolated, and, to a degree, estranged from the world community of physicists. Those of us who knew and loved him were saddened by this turn of events. But we took comfort in the certain knowledge that he was one of that handful whose magnificent contributions made science the great intellectual adventure of the twentieth century.

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