It is likely, however, that the neglect of nuclear quantum effects and the small system size will only influence the quantitative details of the kinetics and not negate the basic mechanism. The calculation of Geissler *et al.* offers both a new perspective on autoionization in water and a challenge. The brave experimentalist who picks up the gauntlet and identifies the predicted transient species will write the next chapter in this story.

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RETROSPECTIVE

Herbert A. Simon, 1916–2001

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Herbert A. Simon, winner of the 1978 Nobel Prize in Economics, died on 9 February at the age of 84. He was Richard King Mellon Professor of Computer Science and Psychology at Carnegie Mellon University. In an era when universities assiduously preserve the names of their new buildings for generous donors, the new Computer Science Building at Carnegie Mellon University is instead named for Simon and another renowned computer scientist, Allen Newell.

The hallmark of Simon's remarkable career is the extent of his cross-disciplinary contributions: from economic theory to psychology to behavioral science to computer science. Before his Nobel Prize, Simon had already won the A. M. Turing Award, the top accolade for computer science, prompting computer scientists to refer to him as "our Nobel Prize winner." But psychologists also awarded him their top honor, the Distinguished Scientific Contribution Award, and they too claimed him as their own.

As his graduate student, in awe of his enormous knowledge and the range of his contributions, I once asked him to explain his mastery of so many fields. His unforgettable answer was, "I am a monomaniac. What I am a monomaniac about is decision-making." Studies and models of decision-making are the themes that unify most of Simon's contributions.

He challenged the assumptions of mid-20th century economic theory, the so-called Rational Economic Man model. This model assumed the omniscience of human decision-making: that humans recognize all of their possible choices and the consequences of selecting each. Simon, the empiricist, observed that Rational Economic Man does not exist. The cognitive ability of people to recognize alternatives and calculate optima is in fact quite limited. He argued that economics could not be built upon a foundation of assumptions concerning human behavior that were patently false.

As a substitute, he introduced assumptions of bounded rationality and the concept of "Satisficing" Man, who cannot maximize or minimize because the computational demands of doing so are beyond his capability. Satisficing man makes choices that are satisfactory—good enough, rather than the best. In the early 1950s, Simon introduced his theory with two classic papers in which he argued that objects (real or symbolic) in the environment of the decision-maker influence choice as much as the intrinsic information-processing capabilities of the decision-maker. In his book *The Sciences of the Artificial* (*1*), with his usual expository skill, he made this idea easy to grasp. His metaphor was the ant on the beach: The ant makes her way from a starting point to a food source along an intricate path. But the path appears to be complex only because of the patterns of the intervening grains of sand, not because of any complex information-processing by the ant.

Collaborating with James March, Simon applied the search model of problem-solving to the study of how organizations make decisions and how they innovate. Their book, *Organizations* (*2*), is the foundation of modern organization theory. March, Richard Cyert, and others extended Simon's theory to microeconomic phenomena in the influential book, *A Behavioral Theory of the Firm* (*3*).

Simon, the theorist, sought to give these abstractions a concrete expression from which precise predictions of human problem-solving behavior could be made. Simon tried using mathematics but found its language was not rich enough to express the complexity of the problem-solving processes he was attempting to model. With Allen Newell in 1955, he discovered the right language: the language of the digital computer. Newell, Simon, and J. C. Shaw of RAND invented a powerful programming language for describing complex symbol processing. They used their new language to model problem-solving processes such as proving theorems in logic. This marked the start of the field of artificial intelligence and Simon considered this contribution to be his finest. Many computer simulation programs of human cognition followed. Newell and Simon's 1972 book, *Human Problem Solving* (*4*), is perhaps the most important book on the scientific study of human thinking in the 20th century.

For the last 25 years of his life, Simon continued to experiment and build computer models of cognition. He designed models of human expertise, scientific discovery (he modeled how certain historically great discoveries of science were actually made), and human memory. He worked for decades on models of the processes through which symbols are learned, recognized, retrieved, and forgotten.

If one were to read a single book that would encompass the essential Simon, I would suggest the slim volume *The Sciences of the Artificial* (*1*), written for a broad scientific audience. In an elegant and lucid way, Simon explains the principles of modeling complex systems, particularly the human information-processing system that we call the mind.

There is no better epilogue for Herbert Simon than that imparted by one of his Carnegie Mellon University colleagues: As Herb Simon struggled to recover from complications of surgery a few days before his death, this author of nearly a thousand papers and 27 books finished a manuscript he was writing and gave instructions to his daughter about its publication.

The author is professor emeritus of computer science, Stanford University. He was a student of and later a research collaborator with Herbert A. Simon.

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