Molecular Electronics and the Microelectronics Origins of Nanotechnology

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Long before there was nanotechnology, the semiconductor industry was miniaturizing microelectronic components at a rate defined by Moore's Law. Since the late 1950s, the dominant material of that industry has been silicon. Yet there have always been competitors to silicon – technologies that supporters hope will upend the semiconductor industry and bring them competitive advantage. We argue that it is impossible to understand the semiconductor industry without a more complete picture of these alternatives – how they come about, how they come to capture organizational support, what kinds of scientists and engineers champion them, why they fail. We also argue that it is impossible to understand nanotechnology without a focus on these alternatives. Each time one has failed, it has usually been spun into an independent academic research community. Today, those communities form the backbone of the nanotechnology field. We trace the history of the longest-lived silicon alternative – molecular electronics. Molecular electronics arose in the late 1950s as a visionary program conducted by Westinghouse on behalf of the Air Force; we attribute its failure to the difficulties inherent in matching a futuristic vision to a bureaucratically accountable, incremental program that could compete with silicon. Molecular electronics reappeared again at IBM in the 1970s and the Naval Research Laboratory in the 1980s – each time as a futuristic alternative to silicon computing promoted by a talented, charismatic, but fringe scientist. In each of these incarnations it failed to gain the organizational support to become a mainstream technology. Only in the 1990s, with the rise of institutions for nanotechnology and the decline of pipeline models of innovation, has molecular electronics neared acceptance by the semiconductor industry.

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