> perennial favorite in nature's gallery of enviable nanotechnologies. These squishy creatures construct supertough shells with beautiful, iridescent inner surfaces. They do this by organizing the same calcium carbonate of crumbly schoolroom chalk into tough nanostructured bricks. (Amato, 1999, 3)

The shift from "nature technologized" to "technology naturalized" is usually hailed as a new, more friendly as well as efficient, less alienated design paradigm. Rather than force nature into the mold of crude machinery, biomimetic engineering learns from the intelligence and complexity of nature's own design solutions (Rossmann and Tropea, 2004). Here, however, I want to explore a limit of this biomimetic ideal, the limit where technology blends into nature and seemingly becomes one with it. At this limit, the notions of "nature" and "technology" become unsubstantial and lose their normative force: instead of signifying the conditions of life on this planet in its particular cosmological setting, "nature" reduces to processes and principles[3]; and instead of signifying transparency, rationalization, and control, "technology" becomes opaque, magical, even uncanny. This limit is reached when technical agency becomes too small or too large for human experience, and at this limit design for the human scale becomes an ever greater challenge (compare Clement, 1978, 18). As we will see, this limit could also be reached where engineering seeks to exploit surprising properties that arise from natural processes of self-organization.

2 Scientific Understanding vs. Technical Reach

Hooke emphasized that nature will become as intelligible as technology once we see in it the workings of tiny, but ordinary machines. In contrast, the human brand of nanoengineering may end up giving us technology as opaque as nature's alchemy.

> From chalk to abalone shell […] this is the "alchemy" of natural nanotechnology without human intervention. And now physicists, chemists, materials scientists, biologists, mechanical and electrical engineers, and many other specialists are pooling their collective knowledge and tools so that they too can tailor the world on atomic and molecular scales. (Amato, 1999, 4)

In the eyes of many, the promise of nanotechnology is to harness nature's alchemy, its opaque, if not occult, powers of self-organization for the purposes of engineering. At first glance, this appears to be deeply implausible rhetoric. When scientists and engineers tailor the world, surely they do not do so alchemically. They will need to figure out first by what mechanism the abalone transmutes chalk into shell. And when a biological cell is represented as a factory that utilizes nanoscale machinery, we clearly project upon it the mechanical conception of "rotary motion just like fan

[3] While the substantial conception of nature provides an engineering norm (for example, to sustain these conditions of life), only a hollow notion of "biomimetic" design corresponds to nature conceived as principles and processes (von Gleich, 2006).

motors whirring in summertime windows" (Amato, 1999, 4). Indeed, before we take nature as a formidable nanoengineer from which we can learn a trick or two, we must first attribute to it our idea of engineering.

As far as scientifically understanding nature and learning from it are concerned, not much has changed since the time of Hooke (or Kant, for that matter): nature becomes intelligible only to the extent that we can represent it intelligibly in terms of causal mechanisms, be they physical, chemical, or biological. From the point of view of scientific understanding, the difference between the texts from 1665 and 1999 thus evaporates fairly quickly. For the philosophy of technology and questions of design, however, the difference between the two texts remains striking, giving rise to my main thesis: naturalized technology drives a wedge between scientific understanding and technical reach. It requires very traditional conceptions of understanding and control to develop nanoscale devices, genetically modified foods, or smart environments.[4] But once we think of these as technical systems in their own right, naturalized technologies cease to be objects of science and of experience, they take on a life of their own such that we no longer appear to perceive, comprehend, or control them, such that we no longer think of them as mechanisms or something "devised by human Wit," but something instead that has receded into the fabric of uncomprehended nature with its occult qualities.

3 A Closer Look

To obtain a more precise conception of naturalized technology, genetically modified foods may serve as a paradigm example. Here, the technical intervention that makes for a genetically modified plant and thus enters into food remains essentially inconspicuous to human senses. The genetic modification can produce visible and invisible phenotypic traits; these phenotypic traits might then whither away with the plant or literally become consumed, thus cease to exist – and for all we know, this may be the end of the story. However, at least in some accounts, the genetic modification may also persist and continue to act as it passes through our bodies to some untraceable place in the environment. In these accounts we should wonder about health effects, environmental interactions, the Monarch butterfly, and the like. Though they begin as purposeful interventions in nature, genetically modified foods can thus implicate us in a pervasive technical environment that appears to be just as uncanny as brute nature with its germs, viruses, or bacteria on the one hand, its hurricanes, earth-quakes, erosions, and eruptions on the other.

More briefly put, we encounter naturalized technology when, *for all we know*, a technical agency unfolds below or above human thresholds of perception

[4] I use the term "smart environments" to refer to a technological program that also goes by "ubiquitous computing" or "ambient intelligence."