The biomimetic revolution brings a subcutaneous sensibility to physical engineering and information technologies, so that haptic simulators (for example) can model friction, gravity, and resistance, thereby summoning the body's own processes of learning about distant objects. The heft of the hammer in the hand is crucial to knowing how to hit the nail on the head, just as the programmed resistance of a biomimetically engineered haptic tool is crucial to conducting an effective digital simulation of thoracic surgery. So far we are still using subcutaneous models to induce supracutaneous effects. Can we still speak of "interfaces" when research moves toward modeling "the locomotion and sensory systems of lower animals such as parasites, worms, and insects which can burrow and navigate through the substrate (e.g., worms living in mud) . . . to design and make micro-machines which can navigate through the human body"?[5]

I offer below a few philosophical categories that might begin to capture our sensorial relations to such biomimetic initiatives, not to foreclose debate, but to begin the necessary cultural dialogue about this new wave of technoscientific research.

Manipulable biomimetics could describe the hand-size interface, an external feedback device placed comfortably outside our bodies, analogous to the graphical user interface of a computer. We are happily habituated to this realm, since our computers have long been outfitted with biomimetic metaphors such as "drag and click" haptic cues or programmable resistance in keyboard tiles. Indeed, many scientists outside the field of biomimetics proper reveal this haptic sensibility in producing manipulable interfaces for their nanoscale operations (see "Nanofacture").

Productive biomimetics might be useful to designate those studies of biological systems that hope to adapt them to problems in industrial production. This sector of research offers the widest range in proposed scales and objects of application, from crisper potato chips (taking the cell size and distribution from the desired potato cultivar and mimicking them in genetically engineered variants) to fabrics with humidity vents (taking their design from the humidity-triggered "motor" in pinecone bracts) to large-scale construction robots (scaling up the methods of social building insects such as bees and ants).

Internal biomimetics is a term I would reserve for those devices and operations intended to function within the body, under the skin, and (thus far) planned to circumvent the host individual's conscious control. Like the still hypothetical wormbots that will tunnel through the various "substrates" of human plumbing, such internal biomimetic apparatuses are fueled by our insatiable desire to see every system of our bodies *from the inside* and to enlist technologies to repair or maintain these all-too-mortal systems and struts. The scale of such interventions can still range from that of the aforementioned internal defibrillator (always compared to the proverbial pack of cigarettes, still the greatest risk factor for developing heart disease) to the minute cochlear implant that transforms external sounds into electrical signals (directly stimulating the auditory nerve) to synthesized molecular substrates designed to grow biomimetic bone underneath in situ gum tissue.[6]

The operative physical interface of internal biomimesis is inside the body. The question thus arises: Is this frontier still sensorial, or is it *subsensorial?* Will we need to develop a far more subtle sense of our interiors (and more subtle controls for the engineered objects within them)