four to eight small holes between the ribs. Microsurgical instruments are inserted through some ports; others are for imaging cameras that present a magnified three-dimensional view of the surgical site. The first full set of equipment for this minimally invasive heart surgery has been developed by Heartport Inc., Redwood City, Calif. Founded by two Stanford University medical school graduates four years ago, Heartport got the Federal Drug Administration’s approval for 10 human tests last year and expects to carry out a second phase of clinical trials with several hundred patients at centers throughout the United States. Trials abroad are planned as well.

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Enthusiastic reviews of medical advancements lead the public to believe that we live in an age of miracles and wonders. Wonders, yes; miracles, no. It is increasingly feasible to offset the loss of body parts or functions; substitutive medicine keeps growing in sophistication and power. Yet replacement parts decay faster than do their natural counterparts, honed by hundreds of millions of years of evolution. We cannot expect replacements to be successful in each and every case. They will occasionally show defects or complications and cannot protect patients against aging, general wear, or intercurrent diseases superimposed on the original malady. If engineers and medical practitioners are not careful, and patients are not objectively informed about the risks involved and the potential for failure, the emerging field of tissue engineering may create serious disappointments.

The first significant tissue-engineering products are now at the stage of pilot clinical trials; they are being tested on very selective, small groups of human patients. These applications include cell-based skin substitutes for wound dressing and wound healing; corneal grafts to restore vision; bone, cartilage, and ligament repair procedures involving transplanted cells; implants in or next to the brain or spinal chord for the treatment of pain or neurodegenerative disease; endocrine pancreas (insulin) substitution systems for diabetes; liver assist devices and molecular biology. The day is not far off when engineers will view biology as the first, more predictable, step in the treatment of complex diseases.

These developments have affected engineering in several ways. To face the increasingly multidisciplinary challenges ahead, biomedical engineering education must now impart a working knowledge of cell and molecular biology. The day is not far off when engineering circles will view biology as a fundamental science, on a par with chemistry and physics.

At the professional level, the greatest challenge is to establish standards of fabrication technology for “living medical products.” Manufacturing techniques and quality control are hot areas where engineers are uniquely qualified to make their mark. Biomedical engineers may also claim a role as technology gatekeepers, joining with doctors, health care managers, and regulators to determine safety thresholds and cost-effectiveness standards for new medical technologies.

Finally, engineers can expose the public to saner, more realistic expectations about tissue engineering technology. An objective appreciation of the risks, benefits, and cost-effectiveness of emerging therapies—as well as a concern for the quality of life and not merely for prolonging it—are urgently needed to restore the public’s faith in medical technology.

The time has come to abandon the cliché term “life-saving” interventions. In reality, only a minority of medical acts can objectively be described as such. Tissue engineering focuses on rehabilitation and quality of life. It provides an example of the liberating role of technology. The professional, balanced input of biomedical engineers may help it reach its potential.

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