surgeries and other treatments that they replace. Others will be expensive by any measure, reflecting their enormous research costs. These costs could create an ever-widening gap between those who can afford powerful new medicines and those who cannot.

REPLACEMENT HEARTS

Swine hearts. Online discussions with a variety of authorities in what is kosher under the dietary laws of Judaism and under the laws of Islam show little concern that replacing a human heart with a swine heart would be religiously forbidden. Some do not consider surgery to be equivalent to eating. Most cite traditions that suspend such laws when necessary to save a life.

Neo-organs. To grow a heart muscle, you start with a donated human egg cell, substitute genetic material from a cell taken from the person for whom you are growing the heart muscle, and grow the resulting embryo in a laboratory dish to the 100-cell blastocyst stage. Then, you strip off the outer layer of cells, disaggregate the inner cell mass, and grow it into a colony of embryonic stem cells. Finally, you stimulate them chemically to differentiate as myocytes, heart muscle cells.

Until you strip off the outer layer of the blastocyst, the embryo is a human clone. Implanted in a uterus, it could grow into a full human being. To some, this means that it is a full human being and should not be used for any purpose, no matter how noble. To others, it is only a potential human being and does not become a human unless it is implanted in a uterus. Much the same process has occurred without comment for decades in fertility clinics doing in-vitro fertilizations (a number of embryos are created; when one is successfully implanted, the others are destroyed). Yet the idea of using embryonic stem cells has already created controversy and is currently under congressional ban in any laboratory receiving federal funds. Some experimenters believe, however, that neo-organs can be grown from more mature cells—fibroblasts—thus avoiding this particular problem.

PATIENT DATA

Turning medical records into digital data makes copying them far easier and arouses privacy concerns, much the same as the creation of genomic data. The main protection for smart cards is that they require special readers. The main protection for CD-ROM cards and cards with personal identification numbers for Web sites is the patient's physical possession of them.

LIFE EXTENSION

The idea of extending people's lives beyond what seems to be their natural limit is not supported by any ethical consensus. Many physicians consider their goal to be curing disease, easing pain and disability, and avoiding early death—not extending life.

If methods of extending life prove to be feasible, then it is likely that they will be considered medically unnecessary, like cosmetic surgery, and so will not be covered. This means that only the financially well-off will live longer—a situation that is sure to provoke a great deal of ethical debate.

These ethical concerns are likely to slow research in certain areas, delay the adoption of some techniques for general use, and help mold the eventual shape of the technologies that come into use over the next decades. Technology is not some neutral force set apart from people; it is an expression of human desires and world views through scientific means.

Technological Advances and the Next 50 Years of Cardiology: Glossary

Joe Flower, MA, Leonard S. Dreifus, MD, MACC,* Alfred A. Bové, MD, PhD, FACC,†
William S. Weintraub, MD, FACC‡

Because this article is more likely than most articles in the *Journal of the American College of Cardiology* to be read by members of the media and other noncardiologists, we provide definitions of a few of the technical terms used:

Angiogenesis: growth of new arteries; in cardiology, angiogenesis typically refers to the use of new drugs, such as vascular endothelial growth factor (VEGF) to promote the growth of new cardiac arteries that supply the heart muscles with blood.

Angioplasty: various techniques to re-open arteries that have been narrowed or closed by arterial plaque.

Apoptosis: cell self-destruction.

Catheters: long, wirelike instruments typically inserted into large arteries to do work in the heart or the arteries.

Fibrillation: the random and ineffective firing of any of the four vessels that comprise the heart.

Genomic: relating to the genome, the entire pattern of genes in the body; a genetic study would look at patterns passed down through generations in the genes; a genomic study, by contrast, would focus on patterns of genes expressing, or being suppressed, in any given state of health or disease.

Glycosylation: a process by which glucose causes proteins to cross-link into longer and less flexible chains and networks; glycosylation is implicated in many of the common signs of aging, such as wrinkles, glaucoma, the plaques formed in the brains of Alzheimer's disease sufferers, and many of the complications of adult-onset diabetes mellitus.

High-density lipoprotein (HDL): "good" cholesterol, which actually helps prevent cardiovascular problems.

Interventionist techniques: techniques that work through long, thin catheters inserted through tiny incisions into arteries or veins, rather than by inserting larger instruments through incisions in the body.

Low-density lipoprotein (LDL): "bad" cholesterol, which leads to the formation of plaque in arteries.

Minimally invasive surgery: surgery conducted through small ports cut into the body; the surgeons use long tools with tiny video lenses, lights, or surgical instruments at the end.

Myogenesis: growth of new muscle; in cardiology, myogenesis typically refers to the attempt to create drugs that will promote the growth of new heart muscles to supplement muscles that have been damaged by myocardial infarction or other heart disease.

Nanotechnology: the art and craft of creating molecular-scale machines.

Proteomic: relating to the "proteome," the entire pattern of proteins in use in the body; while a genomic study would focus on patterns of genes expressing, or being suppressed, in any given state of health or disease, a proteomic study would look at the patterns of proteins that those genes are building.

Restenosis: reclosing of arteries after angioplasty.

Stents: mesh tubes placed in arteries to keep them open.

Reprint requests and correspondence: Joe Flower, What If . . . , 42 Heather Way, Larkspur, California 94939. E-mail: bbear@well.com.

REFERENCES

1. "Genomic Medicine and Novel Molecular Therapies in Cardiovascular Medicine," Victor Dzau, Bishop Lecture, American College of Cardiology Annual Scientific Session, New Orleans, March 1999.
2. MHSS 2020 Focused Study on Biotechnology and Nanotechnology, Military Health Services System, Deputy Assistant Secretary of Defense (Health Affairs), Prepared by SRA International, Inc, July 29, 1997. Summary available at fbox.vt.edu:10021/arch/psk/papa6664/smith/mhss2020.htm.
3. "The Incredible Shrinking Laboratory," Corinna Wu, Science News, volume 154, 8/15/98, pp 104–5.
4. Francis Collins, American College of Cardiology Annual Scientific Session, New Orleans, March 1999.
5. Postgraduate Medicine: New Developments In The Dietary Management of High Cholesterol: A Special Report, November 1998, passim.
6. "Avocado, Fish, Antioxidant fruites and vegetables are winners for Cardiac-conscious diets," presentation, ACC 48th Annual Scientific Session, New Orleans, March 9, 1999.
7. Miettinen TA, Puska P, Gylling H, Vanhanen H, Vartiainen E. Reduction of serum cholesterol with sitostanol-ester margarine in a mildly hypercholesterolemic population. N Engl J Med 1995;333:1308–12.
8. "There's Something in your Food," by Sylvia Rector, Detroit Free Press, April 14, 1999.
9. Yochum L, Kushi LH, Meyer K, Folsom AR. Dietary flavonoid intake and risk of cardiovascular disease in postmenopausal women. Am J Epidemiol 1999;149:943–9.
10. "Vegetable, fruit antioxidants reduce heart risk," Reuters, 5/15/99.
11. Benecol: www.benecol.com
12. "Software gives doctors 3-D view inside patients," Associated Press, 3/1/99.
13. Vital Images: www.vitalimages.com
14. Abiomed: Abiomed, Inc., Annual Report 1998; www.abiomed.com Interview with Abiomed officials, American College of Cardiology Annual Scientific Session, New Orleans, March 6–10, 1999..
15. Votapka TV, et al. Heart transplantation charges: status 1 versus status 2 patients. Heart-Lung Transplan 1995;14:368–72.
16. Interview, Dr. Jeffrey Platt, Mayo Clinic Xenotransplant Institute.
17. Biotechnology Industry Organization: www.bio.org/whatis/editor_welcome.html.
18. Search for Cross-Species Transmission of Porcine Endogenous Retrovirus in Patients Treated with Living Pig Tissue, K. Paradis et al., Science, 8/20/99 (285:1236–1241, 1221–1222).
19. Sullivan S. Nature Biotechnology (vol 17, p 1083).
20. Georgia Tech Researchers Develop First "Smart T-shirt," Victor Rogers, Georgia Tech web site [www.news-info.gatech.edu/news_releases/tshirt.html], 11/14/97.
21. MCB Digital Media: www.romcard.com
PersonalMD.com
22. Interview, Dr. Jeffrey Platt, Mayo Clinic Xenotransplant Institute.
23. "Advances In Engineering Heart Tissue Reported By MIT Scientists, Colleagues," Science Daily—9/29/99. Papers cited: Bursac et al., American Journal of Physiology, August 1999; Carrier et al., Biotechnology and Bioengineering, September 1999.
24. "Building Molecular Machine Systems," K. Eric Drexler, PhD., Trends in Biotechnology, January 1999, Vol 17 No 1, pp 5–7, available at: www.imm.org/Reports/Rep008.html.
25. Institute for Molecular Manufacturing: www.imm.org.
26. NASA Ames: science.nas.nasa.gov/Groups/Nanotechnology.
27. "NASA applications of molecular nanotechnology," Globus et al., Journal of the British Interplanetary Society, volume 51, pp. 145–152, 1998, available at science.nas.nasa.gov/Groups/Nanotechnology/publications/1997/applications.
28. "The Potential of Nanotechnology for Molecular Manufacturing," Nelson and Shipbaugh, Rand Corporation, 1995, available at www.rand.org/publications/MR/MR615/mr615.html.
29. "NASA applications of molecular nanotechnology," Globus et al., Journal of the British Interplanetary Society, volume 51, pp. 145–152, 1998, available at science.nas.nasa.gov/Groups/Nanotechnology/publications/1997/applications.
30. ibid.
31. Francis Collins, American College of Cardiology Annual Scientific Session, New Orleans, March 1999.
32. Interview, Dr. William Hazeltine, founder and president, Human Genome Sciences.
33. Kristen Philipkoski, Power to the Patient, Wired News Med-Tech, 20. Oct. 99.
34. Biotechnology Industry Organization: www.bio.org.
35. The Long-Term Intervention with Pravastatin in Ischaemic Disease (LIPID) Study Group. Prevention of cardiovascular events and death with pravastatin in patients with coronary heart disease and a broad range of initial cholesterol levels. N Engl J Med 1998;339:1349–57.
36. Meyer FP. Pravastatin and coronary heart disease. N Engl J Med 1999;340:1115–6.

37. "Cardiologists puzzled at neglect of cholesterol-busting drug," Daniel Haney, Associated Press, 8/3/99.
38. "Merck looks to make cholesterol drug available over the counter," Associated Press, 4/7/99.
39. Interview, Dr. William Hazeltine, founder and president, Human Genome Sciences.
40. Interview, Dr. Tim Henry, Hennepin Medical Center, Minneapolis, MN.
41. "Highly publicized cancer drug also shows promise against heart disease," Associated Press, 4/5/99.
42. "Shutting off plaque's lifeline of blood," Science News #55, p 229, 4/10/99, cites 4/6/99 Circulation.
43. Interview, Michael Schneider of Baylor Medical School, Texas; New Orleans, March 1999.
44. "Age-Old Story," James Kingsland, Inside Science 117, New Scientist, 1/23/99, p 3.
45. Christine Cassel, University of Virginia, lecture at Health Forum conference, Charlottesville, VA, 10/29/98.
46. "Genomic Medicine and Novel Molecular Therapies in Cardiovascular Medicine," Victor Dzau, Bishop Lecture, American College of Cardiology Annual Scientific Session, New Orleans, March 1999.
47. Presentation, Federation of American Societies for Experimental Biology (FASEB) Experimental Biology '99 Meeting, Washington, D.C., April 19, 1999.
48. AVANT Atherosclerosis Vaccine Raises HDL Levels, Reduces Atherosclerosis in Vaccinated Animals, www.avantimmune.com, 4/20/99.
49. Presentation by Dr. David Malin of the University of Houston-Clear Lake at the Society for Research on Nicotine and Tobacco (San Diego, CA, March 5–7, 1999) on Nabi-NicVAX. JAMA #281, p 427, 2/99.
50. Anderson JL, Hallstrom AP, Epstein AE, et al. Design and results of the antiarrhythmics vs. implantable defibrillators (AVID) registry. The AVID Investigators. Circulation 1999;99:1692–9.
51. Azithromycin and Coronary Events Study (ACES): www.nhlbi.nih.gov/studies/aces.htm
52. "Port-Access Heart Surgery Shown To Be Less Costly, Just As Safe As Conventional Procedures," presentation, ACC 48th Annual Scientific Session, New Orleans, March 9, 1999.
53. "Doctor's device lets the heart keep pumping during bypass surgery," Cathryn Prince, Boston Business Journal, 2/8/99.
54. "Surgeons Face Learning Curve with Beating-Heart Bypass Procedure," presentation, ACC 48th Annual Scientific Session, New Orleans, March 9, 1999.
55. Genzyme: www.genzyme.com.
56. Medtronics: www.medtronics.com.
57. Computer Motion: www.computermotion.com
Intuitive Surgical: www.intuitivesurgical.com
58. FDA Approves Extension of Human Clinical Study for Robotically Assisted Heart Bypass Surgery: Three U.S. Centers to Use Computer Motion's Zeus Robotic Surgical System to Pioneer Minimally Invasive Heart Bypass Procedures, August 18, 1999 Business Wire.
59. Computational Imaging Science Group, Division of Radiological Sciences, Guy's Hospital, London: carmen.umds.ac.uk/magi/.
60. Vital Images, Inc., www.vitalimages.com.
61. AccuImage Diagnostics Corp., www.accuimage.com.
62. Fellman B. The Circuits of the Future, Yale Alumni Journal, 11/99.
63. Berkeley: Calif. Engineers Report Chip Breakthrough, Reuters, 11/23, 1999.
64. Collier CP, Wong EW, Belohradsky M, et al. Electronically configurable molecular-based logic gates. Science 1999;285:391–4.
65. Fox M. Washington: Second U.S. Team Takes Step Toward Tiny Computer, Reuters, 11/19/99.
66. Martinez M. Researchers Apply Nanotechnology to Expand Disk Capacity, ABCNEWS.com, 11/19/99.
67. Abiomed: Abiomed, Inc., Annual Report 1998; www.abiomed.com Abiomed officials, American College of Cardiology Annual Scientific Session, New Orleans, March 6–10, 1999.
68. Interview with Flower J., 4/13, 1999.
69. Paradis K, Langford G, Long Z, et al. Search for cross-species transmission or porcine endogenous retrovirus in patients treated with living pig tissue. Science 1999;285:1236–41.
70. "Advances In Engineering Heart Tissue Reported By MIT Scientists, Colleagues," Science Daily—9/29/99. Papers cited: Bursac et al., American Journal of Physiology, August 1999; Carrier et al., Biotechnology and Bioengineering, September 1999.
71. "Fake Veins Deliver The Heart's Desire," New Scientist 11/4/99, citing Sullivan, S., Nature Biotechnology vol 17, p 1083.
72. Ned Seeman, New York University: seemanlab4.chem.nyu.edu.
73. Brookfield, Wis.: New Home Heart Monitoring System Extends Lives, Reduces Costs, BW HealthWire: 9/21/99.
74. HomMed LLC: www.hommed.com.
75. Chabot L. CyberCare acquisition opens doors to a new way of treating patients, South Florida Business Journal 8/23/99.
76. Heidenreich PA, Ruggerio CM, RN, MSN, Massie BM. Effect of a home monitoring system on hospitalization and resource use for patients with heart failure. Am Heart J 1999;138:633–40.
77. Mitchell M. Handhelds help with heart attacks at hospital, IDG.net, 9/3/99.
78. "Wireless MD Announces the First Bi-Directional System Connecting Physicians With All Medical Related Providers," Business Wire, 8/16/99.
79. McNaughton K. Net companies battle for doctors, CNET News.com, 5/12, 1999.
80. "60 More Healthcare Organizations Offer Online Clinical Content to Doctors With MD Consult," BW HealthWire, 4/7/99.
81. Weed LL. Information in practice: New connections between medical knowledge and patient care. BMJ 1997;315:231–5.
82. Problem Knowledge Couplers: PKC Corporation, www.pkc.com.