CHAPTER 5

Mastery Over Life: Promises and Perils of Biogenetics

The advance of medicine has been long and slow. As George Washington lay dying from a throat ailment, his physicians bled him occasionally to "relieve the body of foul humours" – actually draining away the very energy needed to survive. Just a few decades ago, before the discovery of penicillin, we were helpless against wave after wave of tuberculosis, typhoid, plague, smallpox, whopping cough, polio, and other horrible illnesses that swept through society at will. Today, less than 10% of deaths in modern nations are due to infectious disease, while the other 90% are the result of environment, genetics, and lifestyle.[1]

That simple fact sums up the reason medical care is now so complex and expensive and getting more so. Modern medicine is employing advances in genetic engineering, molecular biology, nanotechnology, IT, artificial intelligence (AI), and many other fields to address far more difficult technical problems at the atomic level where life originates. The challenges are so tough that these advances will take roughly two decades to arrive, but they will mark a major leap forward. Just as we are horrified now by the thought of bleeding patients, we are likely to marvel at the clumsiness of today's health practices.

THE MIRACLE OF DNA AND OTHER BREAKTHROUGHS

The summaries below highlight the major breakthroughs we will explore in this chapter. As noted before, references are from www.TechCast.org. Of the eight technologies covered, only telemedicine and artificial organs offer hopes of an impact reasonably soon. All the others depend on converting the discovery of DNA into practical benefits, and that will take hard scientific work and time.

Summary of Medical Forecasts

Telemedicine Electronic medical records, online doctor's visits, robotic surgery, and other uses of IT should curtail exploding costs and improve quality of care.

W. E. Halal, *Technology's Promise*
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Artificial Organs An astonishing range of organs can now be replaced with artificial parts, and the replacement of most major organs is likely about 2015.
Child Traits Despite the sensitivities involved, gender is being chosen now by parents, and it's likely that intelligence, height, and other traits will also come under control.
Grown Organs Tissue engineering, stem cells, and even regeneration of limbs are being used experimentally to repair and regrow almost all body parts.
Cancer Cure It may sound wishful, but nanotechnology and other cures offer the hope of restoring normal lives to cancer patients by 2022.
Personal Treatment Understanding DNA allows treatments targeted to each person, improving health and reducing the side-effects of one-size-fits-all medicine.
Genetic Therapy One of the great lures of biotech is eliminating the 5,000 genetic diseases that plague humankind. Progress is slow, but results are likely about 2024.
Life Extension Average life spans are likely to reach 100 in 30 years or so, and they may even exceed the "natural" limit of 120 years.

Telemedicine

Medicine is probably the least computerized industry in the world. The problem is that healthcare is a very complex field, but it is also stalled by institutional resistance. With out-of-control costs and more powerful IT, however, progressive hospitals are embracing online medical records, virtual exams between patient and physician, robotics, and a host of other forms of telemedicine. These advances should enter the mainstream in about a decade to save hundreds of billions of dollars, greatly improve healthcare, and provide more convenient service.

The enormity of the need is seen in the almost total lack of medical IT. Although physicians now often used hand-held PDAs, it is estimated that 90% of all transactions are still conducted by paper and telephone in the U.S., and electronic medical records are only used by 17% of hospitals. "Medicine remains a paper-driven system," said a professor of medical informatics at Stanford. It does not help that hospitals are bureaucratic, insurance usually does not cover telemedicine, physicians resist computers, and patients are fearful about privacy. And poor information systems often discourage use. After automating a medical procedure, a physician complained, "A task that once took three minutes suddenly devoured half an hour."

But the advantages are equally enormous. Some think telemedicine could save as much as one-third of the $1.7 trillion the U.S. spent on healthcare in 2005; this is expected to reach $2 trillion by 2007, or 20% of the entire GDP. Telemedicine could also eliminate 80% of the 98,000 deaths per year caused by medical errors. Many employers like GM and GE only patronize computerized hospitals because they are able to reduce costs by 30% to 40% while improving service. Dell provides its employees an online healthcare system. "Every corporation is considering this," said the CEO of WebMD. Some telemedicine trends:

Trends in Telemedicine

Electronic Records "Point of care" systems allow health workers to access electronic patient records, make notes, prescribe treatment, and order drugs. While the U.S. lags in electronic records, Finland, Norway, and Sweden have largely converted to electronic systems, while France, Germany, and Denmark are in progress now.[2] China's Center for Disease Control has an IT system that allows daily updates from 16,000 hospitals.

Conference Systems "Teleconferences" allow patients to be seen at a distance and enable medical personnel take diagnostic data. Some 32 U.S. states now provide online consultations, and half of patients say they prefer virtual visits. The data shows quality of care remains unchanged.

Intelligent Diagnostic Systems Complete models of patients are being constructed from medical data to diagnose illness. Computerized diagnosis offered by IBM has been shown to be more accurate than diagnoses by physicians.

Robotic/Telesurgery Use of the Da Vinci robotic surgery system has grown from 1,500 operations in 2000 to more than 20,000 today. A robot guided at an Italian hospital performed the first operation online (heart surgery) on a patient in Boston. A woman in France had her gall bladder removed by a surgeon in New York City.

Exemplars Kaiser Permanente is completing a $2 billion web-based system that will help 10,000 medical personnel serve nine million patients at 362 hospitals. Brigham & Women's Hospital system in Boston uses 30,000 workstations to integrate all healthcare for 700,000 outpatients.

The IT Enabled Physician Physician training is now IT intensive, including the use of PDAs, CD-ROM, and patient simulators. "The computer is the physician's black bag of the future," said the dean of the Harvard medical school.

With such great stakes involved, it's easy to see why many think the computerization of healthcare is inevitable. A survey found 70% of hospitals are planning to adopt telemedicine, and almost all patients think it's a good idea. If hospitals don't move quickly, they may find tech-savvy patients demanding it. Forty million Americans now use the Internet to find health data. Telemedicine is growing 30% to 50% per year, and the CEO of Waterford Telemedicine expects it to cover a large part of all healthcare soon. TechCast estimates telemedicine will be used 30% of the time to maintain medical records, order drugs and lab tests, diagnose illness, monitor patients, and other medical work by 2014.

Artificial Organs

An astonishing array of body parts can now be replaced with artificial equivalents: skin, bone, blood vessels, cochlea, heart valves, pacemakers, knees, hips, etc. Using a combination of computer chips, micromachines, tissue engineering, and other new technologies, artificial organs may soon be available to replace major parts of the human body. "Name almost any human disability," wrote *BusinessWeek*, "and there's probably research underway to overcome it."

Medicine has a long history of success in replacing bodily parts. In the U.S. alone, 150,000 knees are replaced by metal joints each year, to say nothing of pacemakers and heart valves. About 90,000 people have electrodes in their heads to control tremors of Parkinson's disease, and 70,000 have artificial cochleas to restore hearing. Pressure to develop new prostheses is intense because organ donors are in such short supply that 100,000 people die in the U.S. each year while on waiting lists, and organ transplants struggle against immune rejection. The field is advancing rapidly as Moore's Law drives IT forward, so almost all bodily parts could in principle be replaceable with artificial counterparts in no more than two decades.

Artificial arms and legs now use computer chips to coordinate movements, are wired into the nervous system so they can be controlled by normal thought, use sensors to provide a sense of touch, and have micromotors to power joints. Some are designed to precisely match the user's limbs, including freckles and hair. An artificial hand can move all fingers and an opposable thumb.

Researchers have even been working to restore sight. Video cameras are installed in eyeglasses, transmitting images to chips in the back of the eye wired to the optic nerve. Lasik surgery can now map the wavefront of the lens and sculpt it precisely to correct imperfections. Another approach implants a corrective lens into the cornea. An opthomologist estimates, "Artificial vision will soon allow blind people to move around freely; within 25 years they could read."

An artificial heart has been approved for temporary use, along with artificial blood. An artificial kidney is being tested that may eliminate the need for dialysis and kidney transplants. Medtronics Corp. is testing an artificial pancreas that delivers insulin to diabetics. Even the brain is being replaced bit by bit – the ultimate prosthesis. Computer chips are being used to augment the hippocampus where memories are stored. Medtronics and other companies are installing "nueromodulators" – coin-sized chips implanted in the brain to control epileptic seizures, depression, migraine, and other disorders. Unlike drugs, there are no side effects.

Some of this seems ghoulish, especially messing with the brain. But who would have thought a few decades ago that we would be transplanting thousands of hearts every year? And it is disconcerting to know that your life hinges on a piece of machinery that could fail. An artificial heart using a small turbine (rather than a pump) has been developed that is small and durable, but it produces no pulse. A friend with an artificial heart valve spoke of the constant terror he felt wondering if that steady thumping in his chest would stop. He also said it was a great blessing, considering the alternative. TechCast estimates that artificial organs will replace the heart, lungs, kidneys, liver, and other major body parts at about 2020 +/– 4 years.

Child Traits

The selection of children's genetic traits is one of those technologies fraught with controversy. Simple characteristics, like gender, can be selected at will now, and it should be possible to select almost all traits as genetic engineering gathers steam. But people hold different views on the morality of this practice, many considering it a form of "playing God" that should be prohibited, while others think it should be left to the discretion of parents.

In the U.K., 80% of the public disapproves of selecting a child's sex, and the practice is regulated because "The social benefits do not outweigh the possible harm." The Council of Europe bans genetic engineering. It does not help when the media inflames this sensitive issue with talk about "designer babies." Other cultures believe selecting a child's traits is not philosophically different from pro-choice abortion, and it could solve serious problems. For instance, children with serious genetic defects, like Down syndrome, are so stigmatized that they are usually aborted. Three-fourths of fertility clinics in the U.S. provide "prenatal screening tools" to detect and abort deformed fetuses. Patients say "We want to prune this from our family tree forever."[3]

Biogenetics is generally leading to the control of DNA characteristics, however, and it's hard to fault parents who think this is best for the child. Even now, sperm sorting can produce a boy or girl with great accuracy, and in vitro embryos can be selected based on sex with 100% accuracy.

The historic trend is that social norms evolve over time, so medical practices considered taboo often become acceptable. After all, it was once considered wrong to open the human body, transplant organs, or conceive children in vitro. Our experts are impressed with the social barriers, however, so they estimate that it will be about 2030 before 30% of parents are likely to alter genetic traits of their children. It will be interesting to see how this dilemma plays out in the years ahead.

Grown Organs

Imagine the benefits of being able to grow living organs in a laboratory from a patient's own cells, producing replacements that are genetically identical. No rejection problems. No organ shortages. And no end to our ability to repair damaged parts of the body. Human skin, bone, and liver tissues are being produced genetically, and the same method is being extended to create entire organs. Stem cells are being used to regenerate damaged organs and cure intractable disease. One neurobiologist calls them "magic seeds." The ethical dilemmas presented by this research are daunting, as are the scientific challenges. However, some scientists claim a veritable body shop of lab-grown organs will wend its way from labs to patients in about 10 to 20 years.

The need is huge. Worldwide, 150,000 people wait for organ transplants, and many illnesses could be cured by engineered tissue. At least 200,000 people suffer from spinal-cord injury. One million have Parkinson's disease, 4.7 million have congestive heart failure, and millions are diabetic. The gap between the number of people waiting and the organs available is increasing by 10% to 15% per year.

The nascent field of tissue engineering is ready for prime time. Lab-grown bone, blood vessels, skin, and other organs are being tested in humans. A living jawbone, nose, bladders, and an ear have been built by growing cells on a scaffold, while livers, breasts, hearts, and fingers are under way. "Bioprinting" techniques are adapting inkjet printers to "print" layers of tissue using "bioink" consisting of live cells to build entire organs. "We can print any desired structure," the researchers claim. Polymers, live cells, nanotubes, and growth hormones are being injected to repair damaged organs or grow new cartilage and bone.

A variety of methods are being developed to grow stem cells without raising ethical concerns about destroying embryos. Researchers have successfully converted skin cells into stem cells, demonstrating the critical ability to produce stem cells from adult cells. Some think it should be possible to convert adult cells into stem cells by switching genes. Other researchers have converted stem cells into brain cells, offering hope for repairing damaged parts of the nervous system. Researchers have discovered the gene that makes stem cells "pluripotent" – able to grow into any cell of the body.

Applications are underway. The U.S. Food and Drug Administration (FDA) approved a trial to inject stem cells into human brains to treat neural disorders. Abbot Labs, Schering, and Genzyme are harvesting stem cells, growing larger quantities, and coaxing them to generate skin, heart muscle, nerve and brain tissue, and entire organs. "Within four to six years, stem cells could become the regimen for patients with damaged hearts," said a scientist.

It may sound like science fiction, but there is a good chance we may even learn to regenerate organs as some animals do. Mice with certain genes have regenerated heart, toes, joints, optic nerves, and other organs, and cells from the mice produced the same effect when placed in normal mice, suggesting there is a genetic solution. Other trials with mice show a protein can regenerate optic nerves after they have been cut. A researcher called these advances "a new chapter in regenerative biology."

There is a fine line between coaxing cells to grow, however, and "errant" cells that could turn cancerous. One study found that stem cells mutate with succeeding generations, increasing the likelihood of abnormalities. A neuroscientist at the U.S. National Institutes of Health noted, "Stem cells may be more cancer-prone."

Organ transplants and other common procedures today were considered equally dangerous not too long ago, so these problems might be overcome in time. Our studies show it is likely that organs will be produced genetically to replace major body parts (kidney, liver, heart, etc.) about 2027.

Cancer Cure

After decades of limited progress, today smarter drugs, nanotechnology, molecular biology, and genetic engineering are producing far more sophisticated treatments that are more effective and safer. “I think we are going to see a revolution in cancer prevention and treatment in just a few years,” said a scientist.

Ninety tests are available to detect cancer earlier and more accurately. There were only ten cancer drugs in ’95, but more than 400 are in testing now. Two new drugs – Tarceva and Avastin – can shrink tumors 90%, making the disease manageable. A vaccine for pancreatic cancer raised two-year survival rates from 15% to 76%.

The most promising treatments include 60 or so forms of molecular biology and nanotechnology, which are especially useful because these tiny molecules and intelligent devices can kill cancer cells precisely with no side effects. Nanotech agents can be designed to seek out cancer, they are small enough to enter the cells and destroy them, and are safely removed later by the kidneys. Some trends:

Trends in Cancer Treatment

Microbiology RNA molecules 25 to 40 nanometers wide are perfect for identifying cancer and carrying drugs to destroy it. “Biomarkers” can identify early signs of cancer by detecting aberrant gene behavior. Molecules called “dendrimers” are used to deliver drugs precisely to cancer cells. A researcher said “We have not had an efficient system to deliver drugs. This is an incredible accomplishment.”

Designer Bugs Bacteria are being designed to seek out cancer, enter the cells, and produce a toxin that destroys them. “Bacteria are the ultimate in smart drugs,” said a geneticist.

Smart Nanotubes Silicon nanowires detect cancer and also indicate the cancer type. “These devices distinguish among molecules with near perfect selectivity,” said a researcher. Metal-filled or coated nanotubes are able to detect and destroy cancer by delivering drugs or other agents Bundles of nanotubes act as lasers when exposed to radiant energy, destroying cancer cells with bursts of light.

Bioengineering DNA is placed in nanocapsules to deliver genetic therapy for curing the biological cause of cancer. Nanobodies consisting of extremely small proteins have an ability to fight foreign bodies, but are small enough to penetrate tumors and other dangerous cells. Researchers have found mice that are totally resistant to cancer. Injecting their white blood cells into other mice with cancer killed all the cancer cells.

Basic Causes "Cancer stem cells" have been discovered that resist standard chemotherapy and go on to trigger regrowth of tumors. "We hope to destroy the engine responsible for treatment failure and recurrence," said a researcher.

Large Data Bases The U.S. is planning a Human Cancer Project bigger than the Human Genome Project. The National Institute of Health (NIH) will spend $1.35 billion over nine years to identify mutations that cause cancer, which will form a "Cancer Genome Atlas." A researcher said "Knowing [genetic] defects points to the Achilles heel of cancer."

Andy von Eschenbach, head of the U.S. National Cancer Institute, thinks cancer could be eliminated as a cause of death by 2015. Our experts are not quite as optimistic. They think life expectancy of cancer patients is likely to approach normal life spans by 2022, allowing cancer patients to recover and lead full lives.

Personalized Treatment

Like most things in life, people vary enormously in their genetic susceptibility to illness, drugs, and other factors, making one-size-fits-all healthcare often ineffective and at times highly damaging. The generalized approach is only 40% to 50% effective and often produces serious side effects. More than 100,000 people die each year in the U.S. from side effects of drugs, and another two million become seriously ill. Now that the human genome is being analyzed carefully, researchers are moving toward genetic tests to determine these differences and thereby permit precise medical treatments that are more effective and safer. The Director of the MIT Genome Center called it "The framework for the future of medicine." Here are some signs of progress:

Trends in Personalized Medicine

Testing Companies now offer genetic tests for a few hundred dollars to determine predisposition for cystic fibrosis, blood clotting, breast cancer, and other diseases.

Costs Dropping In 2006 it cost $10 to 20 million to sequence a person's DNA, but rapid technical advances are expected to reduce that to $1,000 in a few years. The National Human Genome Institute is developing "nanopore" technology that could slash the cost of mapping DNA in five to ten years. Dr. Craig Venter, who deciphered most of the human genome, launched the world's largest genome sequencing center to make genetic tests commonly available. "Our goal is to do an entire genome analysis in minutes or hours," he said.

Identifying Differences Research is identifying which patients will respond to different cancer drugs. IBM and the Mayo Clinic are developing a system that analyzes a person's medical history and DNA to spot likely illnesses. Other studies show a pronounced interaction between foods and genetic activity. "When you consume food, your genes light up like a Christmas tree," noted a scientist.

Advanced Diagnosis "Breathalyzers" can accurately detect the chemical traces of cancer, TB, diabetes, and other illness. "Give us the chemical fingerprint of a disease, and we can devise a test for it," one scientist said.

Large Data Bases The "Human Variome Project" is a database of all human genetic mutations, allowing rapid diagnosis of disease. And the "Personal Genome Project" is designed to integrate all medical data on each person. The chief of research at Novartis called this "an important step toward personalized medicine."

Improved Research Methods Personalized medicine could improve drug development by guiding more precise trials using a few hundred patients instead of 3,000 to 5,000. "This is going to change drug development," said the CEO of a pharmaceutical company.

The complexity is staggering. Minute genetic differences must be identified and related causally to specific outcomes from a wide range of drugs. And sensitive social issues are involved. People of different social classes and races react different genetically, which is likely to provoke issues involving discrimination.

But the progress noted above is compelling. Some experts think it will be common for patients to be genetically tested at about 2010. TechCast estimates treatments tailored to individual genetic differences could enter the mainstream about 2018, saving hundreds of billions of dollars and greatly improving healthcare.

Genetic Therapy

Genetic therapy may represent the Holy Grail of medicine because so much illness is inherited from approximately 5,000 genetic disorders that have been identified. The decoding of the human genome has not reached the point where genetic blueprints have been mapped for all these diseases, and the techniques for altering genetic traits remain crude. But experiments have shown promise, as well as dangers.

A famous French trial completely rebuilt the immune systems of children, although three of them subsequently developed cancer because the virus carrying the corrective gene affected other genes inadvertently. Recently, the U.S. National Cancer Institute successfully gave two men new immune systems to combat cancer, although others in the trial died. The researcher said "I consider this proof that it can work."

More than 300 companies are developing genetic therapies involving 500 clinical trials. The journal *Nature* announced the development of "zinc fingers," an amino acid with protuberances resembling fingers that bind to defective strands of DNA and correct the code. "It deletes the miscoded DNA and fixes the problem," said David Baltimore, co-author of the paper. A harmless virus has been shown to cross the notorious "blood barrier" by carrying genes through the bloodstream into almost every muscle cell. Genes are being injected into the heart to stimulate the formation of new blood vessels that alleviate cardiovascular problems. Research is underway to treat blood disorders, Alzheimer's, illnesses of the eye, pancreatic cancer, and skin cancer.

The challenge of identifying genetic defects, delivering corrective DNA into the body, and having the new genes accepted is enormous. But people badly want to be freed of horrible genetic illnesses, and they are using influence to accelerate progress. For instance, the death of President Reagan exerted pressure to cure Alzheimer's.

Nobel Laureate Walter Gilbert thinks the genetic causes of 2,000 to 5,000 hereditary diseases will be understood by 2010, and that cures for most of these illnesses will be commonly available by 2020 to 2030. The Chairman of Amgen estimates "Gene therapy will be in common use by 2025." This agrees with TechCast's forecast that 30% of genetic illnesses are likely to be cured by 2024 +/– 5 years.

Life Extension

Opinions on aging are notoriously controversial, but the evidence seems to be accumulating that life extension is possible. Discoveries are being made in extending the life of cells, repairing damage to the body, replacing organs, curing major illnesses, and improving lifestyles. As a result, trends suggest that human life spans could regularly approach what seems to be the natural limit of 120 years. The challenges and social consequences are enormous, but many authorities are confident the problems can be solved. Let's look at some research underway:

Trends in Life Extension

Telemeres Researchers have identified an enzyme, "telomerase," that causes human cells to replicate hundreds of times beyond what was thought to be the limit of cell reproduction, the "Hayflick Limit."[4]

Resveratrol A substance in red wine – resveratrol – has been found to protect animals from illness and aging. "It's the first example of a drug that controls the aging process. Before, this would be considered snake oil," said a scientist at NIH.

Sirtuins Scientists have found that "sirtuins" are "universal regulators of aging in virtually all living organisms." These genes seems to explain the success of calorie restriction diets, which prevent age-related diseases and prolong life; now the hope is to control sirtuin genes directly to gain these benefits without dieting. Sirtris Pharmaceutials is testing a drug using sirtuins that is a thousand times more potent than resveratrol, and results for extending life spans to 100 years or so look promising. David Sinclair, the lead scientist, says "This will impact humans within a decade."

Anti-Aging Genes A study at Southwestern Medical Center identified the gene in mice that causes the negative effects of age. The Institute that funded the study said, "This could promote healthy aging and longevity in people."

Nanotech Some scientists believe that nanotechnology will provide the means to keep the human body healthy endlessly. Ray Kurzweil foresees "Fleets of computer controlled molecular tools, smaller than a cell, removing obstructions in arteries, killing cancer cells, and otherwise repairing the body."

Research Funding John Sperling, the billionaire who founded the University of Phoenix, has started an endowed research project to study life extension, "A Manhattan Project whose aim is to [solve the problem] of aging."

A particularly prominent advocate of life extension is Aubrey De Grey at the University of Cambridge. De Grey claims all causes of aging are potentially solvable and that life spans will reach 130 years by 2030. But in scathing articles, respected scientists doubt that the seven solutions proposed by De Grey are feasible. Prof. S. Jay Olshansky at the University of Chicago expects mean life spans to top out at 85 years for genetic reasons, and Prof. Leonard Hayflick at the University of California thinks, "Superlongevity is simply not possible." But studies show that such claims have consistently been proven wrong.

Nobody thinks life extension will be a panacea. Accidents, illnesses, etc., will always shorten lives, and many people say they prefer a natural life span. The social consequences of an aging population are uncertain, but they would be huge. Some studies suggest that the extension of healthy lives creates wealth.[5]

But if the visionaries are right, we could approach what appears to be the 120-year natural age limit, and possibly live much longer. One think tank estimates that a child born today will have a 40% chance of living to 150 years. The Director of the Laboratory on Longevity at the Max Planck Institute thinks life spans will increase by two to three years per decade, approaching 130 years by 2050. Integrating all this evidence, our experts estimate that average life spans are most likely to reach 100 years about 2030.

A HARBINGER OF THE AGE OF CONSCIOUSNESS

As the bubble chart shows, telemedicine is likely to enter mainstream use in a decade or so and will help alleviate the escalating costs of healthcare, followed soon by advances in artificial organs. These technologies are well-developed but await social acceptance and over-

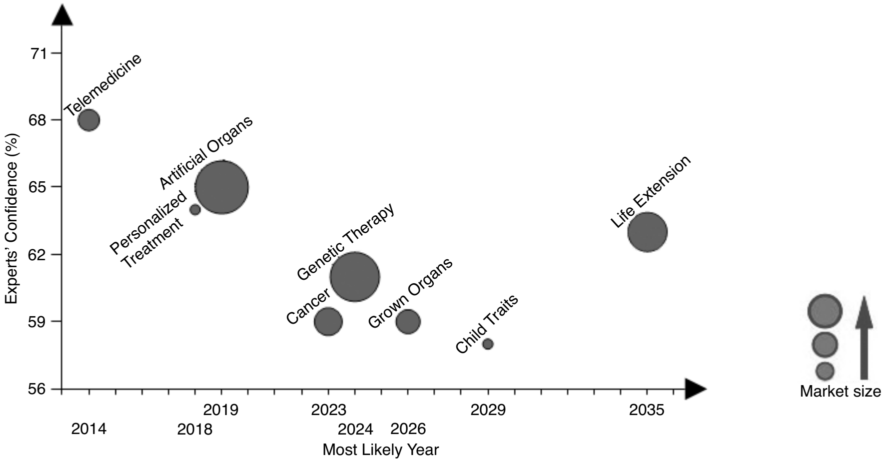

Figure 5.1 Bubble Chart of Medicine and Biogenetics

coming economic and political barriers. The need for artificial limbs, for instance, hardly constitutes a mass market, so the military is supporting research. Healthcare is likely to be more efficient and convenient fairly soon, but patience will be needed as we await the arrival of DNA-based treatments.

These DNA related technologies – personal treatment, genetic therapy, cancer cures, child traits, grown organs, life extension – all require major breakthroughs in biogenetic engineering. Apart from simple tests for genetic disposition to a few illnesses and selecting the gender of a child, very little of this can be done today. It is likely to require another 20 years or so to reach the point where biotech enters mainstream use.

A major obstacle will be the enormous difficulty of reaching accommodations on the delicate social and moral dilemmas involved. For example, the cost of sophisticated treatments is primarily responsible for the uncontrolled rise of healthcare even now, so who is going to pay for the really difficult technologies? Some argue that private healthcare systems amount to a *de facto* form of rationing used to solve this problem. What will happen when the stakes get even higher?

The problem is especially severe because relatively few people take the demanding steps needed to maintain good health. Witness the fact that one-third of Americans are medically classified as obese. I've been involved in a variety of physical disciplines – jogging, yoga, tai-chi, meditation – and I've learned that the body is a beautifully designed product of evolution but it requires a minimal level of care to function well. Many people find it hard to moderate their diet, exercise, control stress, and accept responsibility for their well-being.

And the impasse over abortion, euthanasia, stem cell research, and cloning is simply a foretaste of the far less palatable choices yet to come. Who will decide which traits parents are allowed to select for their offspring? If it were possible to genetically engineer a genius-level IQ, should parents be permitted to create this advantage for their children? How will employers, insurance companies, and potential mates welcome the news that you are genetically predisposed to a serious disease? And with research producing part-human, part-animal "chimeras" that can be used as living factories to produce organs for transplant into humans, the moral issues surrounding bioengineering become very murky indeed.

These worries pale in comparison to more troublesome possibilities. Were you shocked when cruising the information superhighway became stalled by viruses, spam, hackers, and identity theft? Wait until you see their biological equivalent – biohackers – bright kids and terrorists inventing all manner of clever biological agents that can do harm through insidious biological pathways. Were you frightened by the threat of the Ebola? AIDS? SARS? Our waste products contain so much biologically active material that the microbes seem to be evolving more quickly, requiring massive research efforts just to stay ahead of their destructive power.

The range of mischief we are moving toward is limitless precisely because the power of these new technologies is so vast. Yes, it's wonderful to gain mastery over the forces of life, to design almost any type of organism, cure almost any illness, live for hundreds of years, and so forth. And it makes sense from an historic point of view. We have now mastered almost all aspects of the physical world with atomic power, space flight, etc. Why shouldn't mastery of the living world be next?

Biogenetic engineering is likely to confer mastery of life processes, but this God-like power will require more sensitive moral awareness and intense self-discipline to manage such terrible dilemmas. In that sense, advances in medicine represent a harbinger of what is to come generally throughout the social order – the unavoidable need to cultivate a higher-level of consciousness, as we will see in Chapter 9.

Notes

1 Center for Disease Control. www.cdc.gov.
2 Robert Charette, "Dying for Data," *IEEE Spectrum* (October 2006) pp. 22–27.
3 Buchanan, *From Chance to Choice* (Cambridge University Press, 2000).
4 Stephen S. Hall, *Merchants of Immortality* (NY: Houghton-Mifflin, 2003).
5 "The Health and Wealth of Nations," *Science.* (2000) Vol. 287, pp. 1207–1209.