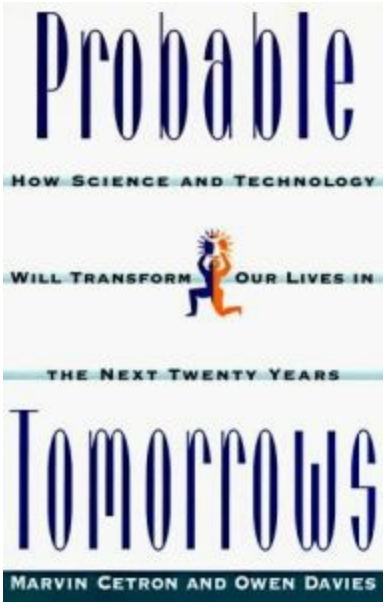

Book Probable Tomorrows

How Science and Technology Will Transform Our Lives in the Next Twenty Years

Marvin Cetron and Owen Davies
St. Martin's Press, 1997

Recommendation

Authors Marvin Cetron and Owen Davies examine anticipated trends in technology over the next 15 to 20 years. They categorize their studies under digital systems, the Internet, high-tech materials, nanotechnology, transportation, space, energy, medicine and environmental remediation. They examine specific technological proposals and estimate their chances for success within the next two decades. An appendix lists specific predictions and the probability that each will come to pass. The book is necessarily superficial, since it covers such a broad range of topics. Unavoidably, some predictions are already somewhat dated, particularly those about industries that undergo constant, rapid change, such as medicine, computers and the Internet. However, the book provides a thorough survey of the range of technologies that are under study and development. This book is a rich source of ideas and makes interesting connections among disparate technologies. *BooksInShort* recommends the book to all corporate planners, trend-researchers and long-term thinkers.

Take-Aways

- Almost everything will have an electronic brain of some kind.
- Microchips will continue to get smaller and faster. DNA computers are coming.
- You will get connected to everything and everyone.
- The Internet threatens to create a two-tiered society, an upper class of prosperous users and an under class of non-users.
- The near future will bring great scientific advances in specialized materials.
- Nanomachines will bring changes as profound as the industrial revolution, antibiotics and nuclear weapons all rolled into one.
- Sources for 'clean' energy will be developed, including photovoltaic cells, biomass and fusion.
- Cleaning up environmental damage in the former Soviet Union is a huge task.
- With advances in gene therapy that use man-made viruses, doctors will be able change genes in the cell.
- Hormone replacement therapy may virtually stop the symptoms of aging.

Summary

Get Ready for Digital Everything

Ten years from now, computers will be almost everywhere, smaller and lighter than you can imagine today. Formerly separate technologies will merge. This convergence will affect television, radio, telephone and computers. The trend toward 'Digital Everything' means that almost every device will have an electronic brain of some kind.

> "Technology is the dominant force of our time and probably of all time to come. It permeates and shapes our lives at every turn."

Microchips will continue to get faster and smaller, thanks to greater component density and more sophisticated design. Data processing will be faster, as technology smoothes out bottlenecks. New processors will perform several instructions at once. Chip designers will begin to reach the limits of miniaturization, but they will get help from x-ray lithography. Scientists are just beginning to build DNA computers, which can represent binary data as patterns of DNA and, thus, use chemical reactions to solve problems. DNA computers are already fast and efficient but at the moment it takes a week to read their results. Super-fast quantum computers remain far off, but optical computers could come into use soon.

> "Computers are becoming so small, powerful and cheap that soon almost any object more complex than pottery will be equipped with its own brain."

In computer software, Object Oriented Programming (OOP) promises to make software more reliable to use and cheaper to create. OOP breaks down software into interchangeable parts. Artificial intelligence will make software more user-friendly and efficient. Intelligent "agents" will perform such tasks as searching for your favorite TV programs or articles.

Connected to Everything and Everyone

Soon, most people will have access to new, powerful online networks. Manufacturers are adopting just-in-time (JIT) manufacturing, which keeps inventory to a minimum. JIT requires suppliers who can deliver goods almost instantly and a reliable flow of information at all stages of manufacturing. When suppliers and manufacturers network their computers, the system works even better. This translates into better customer service and larger profits. In 10 years, most companies will route orders and shipping information over the Internet. Customers will be able to order exactly the products and features they want.

> "The DNA computer is at its best when dealing with huge calculations that can be handled conveniently by trillions of processors - the DNA molecules -all working in parallel."

Telephone companies and cable systems will compete to provide high-speed Internet connections. Many electric companies have already installed fiber-optic networks leading almost to the customer's door. These networks have plenty of excess capacity and could be adapted to provide Internet service. Wireless providers may also compete for this business, including the proposed nine-billion dollar Teledisc system using 840 satellites to provide an 'Internet in the sky.' Wireless data systems will keep you in touch around the world.

> "The next 10 years will fix the character of the Net, probably for decades to come."

The Internet also threatens to create a two-tiered society, with an upper class of prosperous users and an under class of non-users. Since the Web was developed with public funding, some say everyone should have access to it. This could be funded by mandatory private subsidies or government subsidies. Public data terminals could be provided at taxpayer expense, for instance, in libraries. So far, governments have largely maintained a "hands off" attitude toward the Internet. The free market rules.

Materials Science: Bricks for the Future

The near future will bring great advances in materials science. High-temperature superconductors will save vast amounts of electricity that is now lost overcoming resistance. Superconducting microchips will run 10 to 100 times faster. Superconducting magnets could lead to magnetic levitation, or 'maglev,' that would power trains and magnetohydrodynamic engines in ships. Superconductors will reduce fossil fuel consumption.

> "Near-microscopic robots will 'grow' automobiles -or anything else - from vats of raw materials."

Intelligent materials can be manufactured with built-in nerves or muscles that will sense their own condition and adjust to compensate. Currently, shape-memory alloys return to their original shape when warmed. Piezoelectric, electroheological or magnetoheological materials can be used to govern the properties of intelligent materials. Inspired by the way life assembles complex structures, science is pursuing self-assembling materials. Scientists hope to create error-free, self-assembled computer chips, using new materials with new properties.

Nano Technology: Engineering, One Atom At a Time

In the future, certain kinds of goods will no longer be built by hand. Instead, products will be grown from raw materials by virus-sized machines. This nanotechnology would revolutionize medicine, enabling doctors to tinker with individual cells or unclog arteries. Nanomachines could scavenge carbon dioxide from the air, eliminating the greenhouse effect. These machines may eventually be able to turn carbon dioxide into synthetic petroleum or even edible protein. Nanomachines would be only a nanometer (one billionth of a meter) across. Private researcher Dr. K. Eric Drexler predicts they will bring changes as profound as the industrial revolution, antibiotics and nuclear weapons all rolled into one.

> "Until recently, it took some four decades for the discoveries of pure science to find their way into the everyday miracles of technology. Today, that development cycle has been reduced to a few months."

The scanning tunneling microscope (STM) - which can manipulate atoms one at a time - is the first practical tool that promises real nanotechnology. Physicist Don Eigler of IBM has used the STM to make single-atom switches. He has proposed computer memory based on STM. Both are now impractical. STM sensors are much closer to being developed. These sensors could detect tiny quantities of toxins, allergens or viruses.

> "Almost certainly, medical research will extend the healthy human life span beyond the century mark."

Nanochemistry is another innovative approach. Instead of building tiny machines, nanochemistry could be used to build large molecules. Some natural biomolecules are almost as big as proposed nanomachines, and many are self-assembling. Scientists are trying to duplicate this behavior. Nanochemistry may also lead to the invention of electronics based on organic molecules. One scientist envisions a protein computer that recognizes patterns. Despite this speculation, mass production of nanotechnology does not seem close. Nanotech products probably won't appear till after the year 2010, but the nanocomputer may appear by 2025. The real miracles are more than 20 years away, but they are technically possible.

The Revolution In Transportation

Traffic is choking the world's cities. Onboard navigation systems, some using the Global Positioning System, will keep drivers from getting lost and help them avoid traffic jams. Infrared sensors will help cars drive through fog and alert drivers to unseen hazards. The development of smarter cars, which can communicate with each other, will allow cars to be packed together more closely on roads. New fuels will combat air pollution. Electric cars have proven to be limited. Consumers have been slow to adopt them and manufacturing their batteries may cause more pollution than car exhaust. Alternative automotive fuels include compressed national gas, liquefied petroleum gas, hydrogen and ethanol/methanol. Drivers will probably end up with hybrid vehicles that use a combination of electricity and fossil fuels.

> "The first decade of the 21st century will be one of the most remarkable and productive in the history of medicine - not just in history to date but in all the history there will ever be."

In the early 21st century, passengers will move away from cars and airplanes and will travel by train. Despite political resistance, high-speed rail systems are being installed in the United States. Shipping will also benefit from new designs, including hydrofoils, air-

cushion cargo ships and magnetohydrodynamic thrusters. Another promising technology is wingships, based upon a once-secret technology developed by the Soviet Union. Wingships fly on a cushion of air trapped between the wing and the surface, either over water or land. They are unaffected by rough seas and are more efficient than airplanes.

The Long Climb Back Into Space

In the next 15 years, humanity will not return to the moon or launch a manned mission to Mars. These goals are technologically feasible, but there is no political will to achieve them. NASA's Reusable Launch Vehicle project hopes to develop the next generation of space vehicles. There are several designs under consideration. The X-33 Advanced Technology Demonstrator is intended to be the first single-stage-to-orbit vehicle. It is meant to need only 96 hours between flights. However, funding is uncertain. The European Space Agency will continue to follow a conservative path, as will Japan. NASA seems unlikely to find any new purpose capable of re-energizing the U.S. space program. Several potentially profitable space industries include remote sensing for agriculture and resources, satellite solar power for remote areas, space burial and even a space theme park. The biggest market remains communication satellites. Several private companies are developing low-cost launch vehicles and hope to test them in the next few years.

Clean Energy

Fossil fuels have tremendous costs. They create the greenhouse effect and cause dangerous climate changes. Since fossil fuels must be imported to most countries, developing nations spend huge portions of their wealth on energy. Fossil fuels also require distribution. With a few exceptions, most energy sources (including fossil fuels) ultimately get their energy from the sun. The most promising renewable energy sources involve harnessing heat or light from the sun. Photovoltaic cells are becoming more efficient and offer great promise for developing areas. By 2010, it will be cheaper and simpler to use photovoltaic cells than to expand large-scale power projects.

> "Already it is becoming inescapably clear that few environmental problems will wait until we find it convenient to deal with them."

Solar thermal power (ST) uses the sun's heat to drive a generator. ST power can already compete in the marketplace with oil and coal generators. Wind generators are improving and produce energy as inexpensively as hydropower. In the long run, the best alternative is fusion power, which uses abundant fuels, is cheap and, compared to nuclear fission, produces little radioactive waste. Several decades of work will be required to bring fusion reactors on-line, but within 15 years the public should know that the technology will be feasible.

Nursing an Injured Planet

The most pressing environmental issues of the next 15 to 20 years include: 1) A huge clean-up will be needed to address environmental damage in the former Soviet bloc, especially Russia. 2) Science will finally pin down the effects of industry on the atmosphere, including both the greenhouse effect and the effects of sulfate compounds. 3) Loss of ozone will continue to pose a health risk throughout the world. Physicist Alfred Wong proposes breaking down ozone-depleting chemicals by the relatively-inexpensive measure of using a fleet of blimps to drag football-field sized arrays of electrically charged wires through the sky. 4) Water is growing scarce worldwide. Desalination requires too much energy. The world will adopt smaller scale measures to improve water use. Many international bodies will take up the problem of water over the next 20 years.

Medicine for the New Millennium - Making Aging Stop

The development cycle for new medicines has been shortened to a few months. Hundreds of new treatments will be available to patients. Among the most important are:

- Gene therapy: Using man-made viruses, doctors will be able to alter genes in the cell. This will provide cures and preventions for hereditary diseases. It may also reduce susceptibility to diseases with a genetic predisposition.
- Hormone replacement therapy: Increasing levels of human growth hormone, melatonin and other hormones may virtually stop the symptoms of aging.

- Rejection-free transplants: New drugs will eliminate the need to match organ donors and recipients. Even animal organs will be usable. Science will try to grow organs in vitro.

About the Authors

Marvin Cetron is founder and president of Forecasting International. A resident of Virginia, he has been a consultant for more than half of the *Fortune* 500 companies in the U.S. and for various government agencies internationally. New Hampshire resident **Owen Davies** is a former senior editor at *Omni* magazine and a freelance writer specializing in science, technology and the future. Together, they wrote *Crystal Globe, Educational Renaissance* and *American Renaissance*.
