

Report from the new frontier

By Ann Baker

The opportunities emerging at the intersection of biological science and information technology are staggering. The effects are being felt already in the pharmaceutical and healthcare sectors. But as the new bioeconomy expands, it will also transform industries ranging from banking and insurance to electronics and high tech.





Imagine a world in which automobile sensors disable your car's ignition when you are intoxicated. A world in which your fingerprint or iris signals your home security system and activates a cash machine. A world with cheaper, more abundant and more nutritious food whose cultivation depends less on fossil fuels and uses chemicals produced cost-effectively from renewable sources. A world in which you live a longer, healthier life with greater control of your own well-being.

Welcome to the bioeconomy.

Far from fantasy, the bioeconomy is emerging now, bringing new opportunities in almost every industry. Mining companies, for example, already use microorganisms to consume minerals and ores. Scientists have transplanted fish genes into sugar beets to increase the beets' resistance to cold. To prevent fraud and robberies, casinos use face-identification technology to help spot known criminals.

Convergence

The bioeconomy is driven in large measure by the convergence of biological science and information technology. Genomics (the study of genes and their function), proteomics (the study of the proteins that carry out the functions of genes) and pharmacogenomics (the study of the relationship between medicines and specific genotypes) already are generating enormous amounts of data. New technologies, including bioinformatics (which interprets biological data through computer science) and supercomputing (which manages massive amounts of data), are turning that data into rapidly transmittable information.

The opportunities that emerge at the intersection of these two disciplines are staggering. But no opportunity—

and no change this pervasive—comes without challenge. Accenture predicts that by 2006, the energy, utilities, food and agribusiness industries will be transformed in both structure and process. The banking, insurance, chemicals, electronics and high-tech industries can expect a mix of significant revenue increases, cost decreases and the need to invest in new capabilities. However, the most immediate and profound effects will be felt in the pharmaceutical and healthcare sectors.

Pharmaceutical companies have traditionally focused on developing drugs that will meet the needs of large markets; in the near future they will become specialists focusing on unique markets. Insurance actuaries will become obsolete, as genetic science makes it possible to predict with precision each individual's susceptibility to disease and eliminates the need for traditional actuarial analysis. Governments and their regulators will have to develop and enforce new standards for ethical conduct and data security—and quickly. These are only a few of the changes in store.

In 2000 the Human Genome Project, an international public and private consortium, announced that scientists had mapped the entire human genome. This advance promises the ability to manipulate the “software” that determines who we are, how and when we become ill, and how we die. Even now, with relatively few genes decoded, scientists already can analyze an individual's genetic code, determine his or her susceptibility to schizophrenia, Alzheimer's disease and certain cancers, and, in some cases, even intervene with treatments before symptoms appear.

But when the secrets of 30,000 or so human genes are unlocked, scientists will be able to do far more than understand the basis of disease,

develop more efficient drugs and treat previously untreatable illnesses. With genetic testing and early diagnosis, they will be able to replace faulty genes with new ones and tailor treatments and medicines to an individual's needs and profile. They will even be able to change the way people look and behave. Ultimately, they will understand the genetic causes of aging and illness and be able to prolong life.

The journey to this new frontier began in 1953 when Francis Crick and James Watson identified the double-helix structure of DNA. Over the past half century, scientists have deciphered animal, viral and plant genomes—the complete set of genes in a living organism—and come to understand how they function, falter and die.

Intelligent technology

Meanwhile, advances in remote sensing and artificial intelligence technologies have allowed us to create intelligent operating rooms and devices that transmit health information via telephones and personal digital assistants. Eventually such technologies will make the impossible possible.

- Today researchers can produce bioartificial pig blood by growing vessel muscle cells on biodegradable polymer. Eventually lab-grown blood vessels will help doctors produce organs for transplants, and it will be possible to transplant these organs across species.
- Capsules equipped with miniature cameras one day will carry out internal diagnostics.
- Researchers are now developing applications to replace damaged neurons, which could eventually lead to therapies enabling para-

plegics to walk again and improving the eyesight of patients with optic nerve damage.

- One day physicians will heal severed spinal cords, allowing these patients to receive sensory information and even regain motor control.

Because of the convergence of genetic and information sciences, pharmaceutical research departments will soon use intelligent technology to gather patient information from a variety of sources. Networks of distributed processing systems will mine data sources; supercomputing platforms will manipulate genomic data.

Clearly, steps will need to be taken to ensure the secure transmission of

data. Once that is in place, patients will be able to search and manage their medical records, comparing them to available public health information based on genomic profiles.

Patient-centric medicine

The bioeconomy augurs a shift from medicine created for large populations to a focus on the individual patient and the evolution of a patient-centric model of health care. The ability to individualize patients by their genotype and take preventive or corrective action will mean that from the time of birth, the patient will sit at the center of a web of information about diagnoses, interventions and payments.

In the bioeconomy, doctors will no longer control medical information.

Challenges ahead

In the bioeconomy, the transition to a patient-centric healthcare model will create challenges for medical products and services suppliers, as well as for other industries and organizations.

Providers

- Adapting to new treatment/information approaches
- New capabilities: counseling versus treatment
- Investment in information infrastructure
- New specialties emerge
- New institutions emerge
- Education/access to new information

Products companies

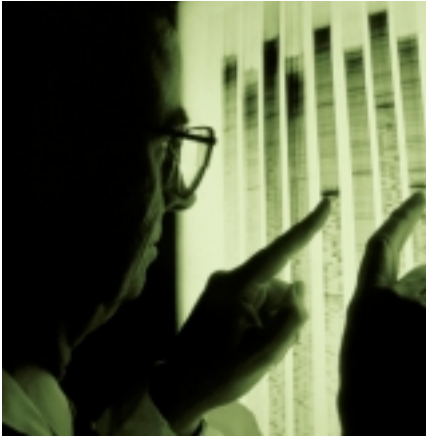
- Closer relationships between diagnostics and pharmaceutical companies
- Restructuring of the pharmaceutical value chain
- Many new entrants
- Access to new science and technology
- Resegmentation of traditional markets and new economic models
- Shift from mass to customized drugs

Insurers

- New reimbursement models
- New risk-management strategies
- New pricing models

Governments/regulators

- New ethical standards
- Data security



Patients will have their medical records in electronic form and will be able to transmit that detailed information anywhere. The Internet already offers profuse information about diseases, drugs and treatments, and patients already are beginning to participate actively in their own care.

As scientists better understand the implications of individual genotypes, they will be able not only to predict an individual's predisposition to diseases but also to treat those diseases preventively. Identifying drug treatments and dosages through trial and error will be eliminated. Analysis of a patient's genetic profile will make it possible to prescribe the right dose of the right drug from the very beginning of treatment—perhaps even before symptoms have appeared.

Smaller is better

As patients gain more control over their treatment, each patient will become a distinct market.

Adapting to that “market of one” will require a change of mind-set and new business models for the healthcare industry. Pharmaceutical companies will need to develop closer relationships with other companies, gain access to new science and technology, resegment traditional markets, restructure their value chains, compete with new entrants and shift from mass-market drugs to customized drugs.

A key challenge for the industry will be producing and marketing drugs specific to smaller and smaller subpopulations of individuals with specific illnesses. For example, instead of beginning the research process with a compound that might lead to a “blockbuster” drug that can be used to treat all asthma patients, scientists will target smaller subpopu-

lations of asthma sufferers based on any one of a range of genetic variations. Then they will use that information to design drugs specifically for those patients.

Down the road, pharmaceutical companies might become disease-specific experts, developing suites of drugs for all genetic variants of a condition such as asthma, rather than casting their efforts across a broad range of diseases, as is the case today. This would provide them with a greater opportunity to move down the value chain into drug delivery, bundling their medications with diagnostic technologies from other companies.

If they become truly specialized, these companies might interact directly with patients concerning the management of a disease. This shift would require changes in most regulatory systems, which currently prevent direct contact between patients and drug companies, and in pharmaceutical companies themselves, since most lack any experience in or knowledge of patient care.

The economics of drug research and development will change accordingly. Today only 1 in 5,000 compounds tested is approved for patient use. But as genomics enables pharmaceutical companies to target segments of patient populations, it will shorten the time needed to identify and validate drug targets, and it will help researchers screen out toxic or less-promising compounds at earlier stages.

As a result, success rates will improve dramatically, and companies will reduce costs by conducting clinical trials on smaller numbers of patients. Of course, this success will force another change: Target markets will be smaller, and pharmaceutical com-

panies will have to undertake clinical trials for—and launch—more products. Given this, they will have to reconfigure their marketing and pricing strategies.

Dissolving the boundaries

As the bioeconomy undermines the pharmaceutical status quo, it will also create challenges for other healthcare players.

- Health insurers, faced with population insurance pools that are no longer useful, will have to develop new reimbursement models, risk-management strategies and pricing models.
- Providers will have to adapt to new treatment and information approaches. Additionally, they will have to focus more on counseling than on treating patients, as preventive medicine for patients with a high predisposition to diseases such as cancer will increase in importance. They will also have to invest in their information structures and enhance their understanding of emerging specialties.
- Diagnostics companies will be moved to partner with pharmaceutical companies to bundle their services with treatments for patients.

Ultimately, we may see the dissolution of boundaries between product and service companies. As suites of targeted products replace traditional blockbuster drugs, for example, pharmaceutical companies may acquire and/or build their own diagnostics and health-service delivery capabilities. And new entrants could target myriad opportunities emerging from this new model, such as:

- Portals of genetic research, grouped by gene, organism and therapeutic area.

- New technologies that enable the flow of medical information from home monitoring devices to healthcare providers.
- Bioethics institutes to debate the ethical, social and legal issues of the bioeconomy.
- Gene trusts or banks where individuals can store and manage their genetic profiles.
- Clinical trials simulators, based on the innovations of the bioeconomy.

The bioeconomy raises important new questions. For example, serious concerns already have been expressed about cloning, the access to genetic manipulation and the specter of eugenics. Who has a right to know whether a patient is predisposed to a certain disease? Will knowledge of an individual's genetic code lead to job discrimination or the inability to purchase life insurance?

Collaboration

Answering such questions will take time and, most probably, the combined efforts of industry, government and third-party organizations such as think tanks and university and religious groups. Despite these concerns, winning pharmaceutical companies will lead the charge into the new environment by starting now to design strategies to address the bioeconomy's challenges and opportunities.

Whatever else happens, it's clear that the bioeconomy's roots are sturdy and deep, and that both industry and consumers are beginning to recognize it. Research departments at some pharmaceutical companies already are incorporating bioeconomic sciences and technologies into their work. Others are considering where

and how to invest so that they can commercialize the practical applications of information drawn from the human genome.

Enlightened executives will recognize the bioeconomy's powerful and widespread influence on changing the way the world lives and will explore ways to capture its benefits to create future value for their companies. For all executives, however, adapting is the only viable option. ■

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