octal, but groups of four binary digits are used. The binary number 00110111, for example, corresponds to the hexadecimal number 37H. The trailing H is used to mark the number as a hexadecimal number. In the case of octal numbers, a trailing O is used.

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—*Raúl Rojas*

Biochips

Biochips are devices that combine electronics with biological reactions. An electronic nose, for example, is a chip that contains many molecular receptors attached to a **silicon** plate; the molecules of some odors bind to the different receptors and the resulting pattern can be analyzed with a computer in order to classify the odor. A notable example of biochips is *microarrays* of DNA strands on an electronic chip, which can be used to detect parts of the DNA code present in a gene. It is then possible to classify genes much faster than with traditional laboratory methods.

Biotechnology is, together with microelectronics, one of the most rapidly growing industrial branches. Both fields deal with extremely small objects, in one case biological molecules, in the other electronic components. Not surprisingly, many researchers have started thinking about ways of building devices that combine microelectronics with biotechnology.

The great book of life is written in the language of DNA. Genes are long DNA chains containing a sequence of only four component nucleotides: adenine (A), thymine (T), cytosine (C), and guanine (G). All genes are written using only these four "letters." Groups of three letters code specific amino acids, which are the building blocks of proteins. Knowing how to read the genetic code, it is also possible to determine what proteins are coded by specific genes. Some medical conditions are caused by defective genes, and therefore, much has been invested in genetic research.

A DNA chain is simply a chain of the four letters, such as ATTAGGCC. The DNA nucleotides have the property of binding to their complementary base (i.e., adenine to thymine, and cytosine to guanine). The complementary chain of the chain above is TAATCCGG. Normally, DNA strands form a *double helix*: One side of the strand has a certain code, and the complementary side has the complementary code. In this way, the double helix is resilient to change and encodes information in a reliable way.

DNA double helices can be broken into their component chains, called *single-strand DNA*. We can synthesize in the lab the chain of three nucleotides with, for example, the code AAA. Now we test if any DNA from a probe gets attached to this small string. We go "fishing" with AAA as the decoy and observe if any DNA from the test tube gets attached to our probe. If this happens, we know that the original chain contains the complementary combination TTT somewhere along the chain.

Now assume that all possible four-letter combinations of the letters A, G, T, and C are tested. There are 256 of them and we would have to repeat the experiment above, 256 times. However, assume that we manage to arrange the 256 four-letter combinations on a small plate (on a 16 by 16 grid). We can now immerse the plate in the probe and by reading out which elements on the grid did bind some DNA from the probe, we then know which of the 256 four-letter combinations are present in the DNA we are testing. This information could already be sufficient to identify a known gene or a genetic defect. The readout of the plate can be done by optical or electronic methods. If we attach some electronic components to each point in the 16 by 16 grid, small configuration changes can be read by electrical means, making the entire decoding of the plate much easier.

Building such plates of *microarrays*, as they are called, is a very time consuming process, better left to a

robot. The machine takes the appropriate pieces of DNA from the appropriate essay tubes and injects them at their place in the grid, using mechanical or electronic methods. The specific mix of DNA strands is selected according to the application. A device of this kind has been called a "lab on a chip."

The market for DNA microarrays was worth U.S.$40 million in 1999 and was projected to grow by 20 times in the following 10 years. New companies such as Cellomics, Genetic Microsystems, Schlummer, Clontech, Affymetrix, and traditional ones, such as **Motorola**, are trying to assert themselves in this market. These companies offer complete solutions (i.e., specific biochips) for certain common problems and "do-it-yourself" kits to put together a customized DNA microarray. Motorola and **Hewlett-Packard** entered a biotechnology collaboration, in which Motorola will supply the biochips and Hewlett-Packard the instruments to do the content analysis.

Biochips can even be used to decode a complete gene. The gene being investigated is broken down into small pieces, smaller or equally long than the sequences on the microarray. By reading the microarray and concatenating the found fragments in the computer, it is possible to decode an entire long DNA sequence in minutes instead of months. Once more DNA information becomes available, it will be possible to build specific chips to test certain genes and its mutants.

Although the technological aspects are fascinating, the limits of application of biochips have not yet been clearly defined. Will it be possible for companies to test the genes of its employees? For parents to test the genes of the fetus? What problems will this bring in the future? Once again, technology is marching faster than society can possibly cope with.

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BIOS

BIOS (Basic Input–Output System) is software that resides in read-only memory (**ROM**) on the computer's **motherboard**; it can also be found on various types of adapter cards. BIOS provides low-level control of the major hardware input–output (I/O) devices, acting as an interface between the software and the hardware. When the computer is first powered on, the first software to run is the BIOS.

The initial **personal computer** (PC) BIOS was designed by **IBM** during development of their PC. IBM contracted **Microsoft** to develop an operating system for the PC and it was agreed that it was to be divided into two parts, one part residing in ROM (i.e., the BIOS), and the other part to be distributed on diskette, the Disk Operating System (**DOS**). Very soon, other companies began to "**clone**" the original PC. To be fully compatible with it or its successors, the IBM PC XT and IBM PC AT, the clones had to write their own BIOS.

BIOS consists of four main parts. Part 1 is a set of routines that test and initialize the personal computer's hardware components, also called the Power-On-Self-Test (POST). Testing is done to check the functionality of the components. If a certain component is not functional, this is made known to the user through one or a series of audible beeps when the video system has not yet been initialized, or by displaying a message to the screen after the video system has been initialized. During all of POST a one-byte code is sent to a special hardware I/O port, usually I/O port 60h. This byte, the POST diagnostic code, can be read using an 8-bit adapter card that utilizes a light-emitting diode (LED) display unit to show a two-digit hexadecimal code. Hardware components are initialized by using default settings or by settings configured through the BIOS Setup Utility.

Part 2 of the BIOS consists of a set of diagnostic routines provided additionally in ROM, or as a supplement on diskette. The most important part of these diagnostics offers a **hard disk** utility, originally to perform a low-level format, auto interleave, and media analysis of hard disk drives. Various BIOSs used to have a far more extensive diagnostic utility to test and analyze all or most of the computer's hardware I/O devices.