The vignette for this chapter in past editions of this textbook described a futuristic scenario of two students taking genetic tests. The future is now. Although entire human genomes can be sequenced, it is more cost-effective to detect only health-related gene variants most likely to be present in a particular individual, based on clues such as personal health, family history, and ethnic background.

Devices called DNA microarrays, or simply DNA chips, can identify inherited gene variants, as well as how particular genes in particular cell types respond to different situations. This information provides profiles that indicate which diseases a person is at highest risk of developing and even how that person will likely react to particular drug treatments.

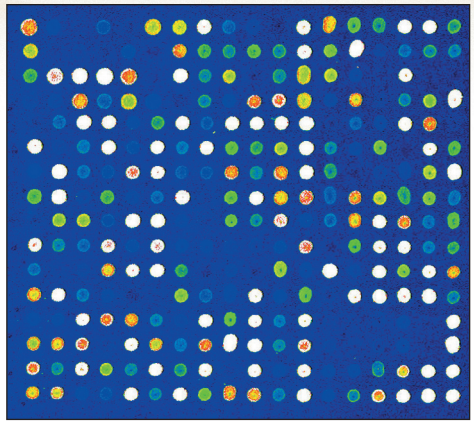
In a practical sense, knowing one's genes can suggest ways to alter controllable factors. For example, one can send DNA collected on a swab brushed inside the cheek to a genetic testing company, and learn which variants of twenty or so genes have been inherited. Nutritionists at the company suggest diets that will help meet personal goals, based on genetic background. Consider the genetic tests that hypothetical college freshmen, Laurel and Peter, face. Each selects tests based on family background.

Laurel's brother, sister, and father smoke cigarettes, and her father's mother, also a smoker, died of lung cancer. Two relatives on her mother's side had colon cancer, and older relatives on both sides have Alzheimer disease. Laurel's tests detect gene variants that predispose her to developing addictions; genes that cause colon or lung cancer; and genes associated with inherited forms of Alzheimer disease.

Peter, who often suffers from bronchitis and sometimes pneumonia, as his sister and mother, takes a test for cystic fibrosis (CF). But he refuses a test for Alzheimer disease, even though his paternal grandfather died of it—he could not bear knowing that the condition lay in his future. Because previous blood tests revealed elevated cholesterol and several relatives have suffered heart attacks, Peter takes tests for gene variants that control blood clotting, blood pressure, homocysteine metabolism, and cholesterol synthesis, transport, and metabolism.

After completing a family history, each student provides a DNA sample from a cheek swab. At a laboratory, DNA in the cells is extracted, cut, tagged with molecules that fluoresce under certain types of light, and finally the pieces are applied to postage-stamp-size pieces of glass or nylon with selected DNA pieces bound. Because the represented genes on the chip are aligned in fixed positions so they can be identified, the device is called a microarray. When light is applied to excite the spots where the dyes bind, the microarray reveals a genetic profile. A genetic counselor explains the findings.

Laurel learns that she is genetically predisposed to addictive behaviors and has a high risk of developing lung cancer—a dangerous combination. She must avoid cigarettes and alcohol and other addictive drugs. She does not have genes that increase her chances of developing colon cancer or inherited Alzheimer disease.



A DNA microarray, or "chip," identifies inherited gene variants, or which genes are expressed (transcribed), and to what degree, in particular cell types under particular conditions. Each dot represents a specific DNA sequence from the human genome. DNA microarrays can confirm diagnoses; predict future diseases; identify sensitivities to environmental agents; and predict drug efficacy.

Peter has mild CF. Another DNA test indicates which antibiotics will most effectively treat the frequent bronchitis and pneumonia. Peter has several gene variants that elevate serum cholesterol level and blood pressure. By following a diet low in fat and refined carbohydrates and high in fiber, exercising regularly, and having frequent cholesterol checks, he can help keep his cardiovascular system healthy. A third DNA panel identifies the most effective cholesterol-lowering drug for him.

Laurel and Peter will add tests as their interests and health status change. Although their medical records are confidential, laws preventing employers and insurers from discrimination based on genetic information are still in flux. The 1996 Health Insurance Portability and Accountability Act passed by the U.S. Congress stated that genetic information, without symptoms, does not constitute a preexisting condition, and that individuals could not be excluded from group coverage on the basis of a genetic predisposition. But the law did not cover individual insurance policies, nor did it stop insurers from asking people to have genetic tests. More than a dozen bills have been introduced in Congress to prevent genetic discrimination, and most states have enacted antidiscrimination legislation.

The new genetics/genomics is changing the face of health care. In the past, physicians typically encountered genetics only as extremely rare disorders caused by single genes. Today, medical science is increasingly recognizing the role that genes play not only in many common conditions, but also in how people react to medications. Disease is beginning to be seen as the consequence of complex interactions among genes and environmental factors. ■