Dr. Leroy Hood, a pioneer of genome sequencing technology, wrote this article for the July 13, 2009, edition of Newsweek magazine. Dr. Hood will be a featured speaker at 2:30 p.m. Wednesday, Oct. 28, at Florida Genetics 2009, the UF Genetics Institute's annual scientific symposium.

Newsweek

A Doctor's Vision of the Future of Medicine

Leroy Hood
NEWSWEEK

From the magazine issue dated Jul 13, 2009

It's June 2018. Sally picks up a handheld device and holds it to her finger. With a tiny pinprick, it draws off a fraction of a droplet of blood, makes 2,000 different measurements and sends the data wirelessly to a distant computer for analysis. A few minutes later, Sally gets the results via e-mail, and a copy goes to her physician. All of Sally's organs are fine, and her physician advises her to do another home medical checkup in six months.

This is what the not-so-distant future of medicine will look like. Over the next two decades, medicine will change from its current reactive mode, in which doctors wait for people to get sick, to a mode that is far more preventive and rational. I like to call it P4 medicine—predictive, personalized, preventive and participatory. What's driving this change are powerful new measurement technologies and the so-called systems approach to medicine. Whereas medical researchers in the past studied disease by analyzing the effects of one gene at a time, the systems approach will give them the ability to analyze all your genes at once. The average doctor's office visit today might involve blood work and a few measurements, such as blood pressure and temperature; in the near future physicians will collect billions of bytes of information about each individual—genes, blood proteins, cells and historical data. They will use this data to assess whether your cell's biological information-handling circuits have become perturbed by disease, whether from defective genes, exposure to bad things in the environment or both.

Several emerging technologies are making this holistic, molecular approach to disease possible. Nano-size devices will measure thousands of blood elements, and DNA sequencers will decode individual human genomes rapidly, accurately and inexpensively. New computers will sort through huge amounts of data gathered annually on each individual and boil down this information to clear results about health and disease.

Medicine will begin to get more predictive and personalized (the first two aspects of P4 medicine) over the next five to 10 years. First, doctors will be able to sequence the genome of each patient, which together with other data will yield useful predictions about his or her future health; it will be able to tell you, for example, that you have a 30 percent chance of developing ovarian cancer before age 30. Second, a biannual assessment of your blood will make it possible to get an update on the current state of your health for each of your 50 or so organ systems. These steps will place the focus of medicine on individual patients and on assessing the impact that genes and their interactions with the environment have in determining health or disease.

In preventive medicine (the third P), researchers will use systems medicine to develop drugs that help prevent disease. If, say, you have a 50 percent chance of developing prostate cancer by the time you're 50, you may be able to start taking a drug when you're 30 that would reduce substantially reduce that probability. In the next 10 to 20 years the focus of health care will shift from dealing with disease to maintaining wellness.

Participatory medicine acknowledges the unparalleled opportunities that patients will have to take control of their health care. To participate effectively, though, they will have to be educated as to the basic principles of P4 medicine. New companies that can analyze human genome variation, like 23andMe and Navigenics, are already planning to provide patients with genetic information that may be useful in modifying their behavior to avoid future health problems. In the future, patients will need not just genetic data but insight into how the environment is turning genes on and off to cause disease—just as smoking often causes lung cancer and exposure to sunlight can cause skin cancer.

P4 medicine will have a big impact on many industries, including pharmaceuticals, food and insurance, as well as health care. The interesting question is whether preexisting businesses and entrenched bureaucracies will be able to respond to these winds of change, or whether a host of new companies will emerge to replace them—focused precisely on these new opportunities.

Research will also have to change. Because most important diseases such as diabetes, cancer, heart disease, obesity and Alzheimer's are so complex, the traditional approaches to studying them have had only marginal results. Powerful new systems approaches, individual measurements and computational technologies will transform our ability to deal with complexity and fashion new drugs and approaches for therapy and prevention.

Medical education will also need to be transformed. Although today's medical students will be practicing P4 medicine within the next five to 20 years, their training is still focused on a classification of disease based on observation of relatively few measurements of health parameters. Tomorrow's physicians will need to be familiar with the complexity of the human biological system as never before, and they'll have to be handy with computer-based tools. Physicians will need to deal with patients who have an enormous amount of information at their disposal. And doctors will need to deal with maintaining wellness more than with disease.

The digitization of medicine—that is, our ability to extract and store disease-relevant information from DNA and molecules in the blood of each individual—together with the revolutionary changes in diagnosis, therapy and prevention will allow those of us in the developed world to export P4 medicine to the developing world and thus transform the quality of its health care. The new P4 medicine will eventually lead to a universal democratization of health care, bringing to billions the fundamental right of health, unimaginable even a few years ago.

Hood invented the genome sequencing technology that led to the decoding of the human genome in 2001. He is a pioneer of systems biology and medicine and founder of the Institute for System Biology in Seattle, Washington.