

Health Care in the 21st Century:

P4 Medicine™: Predictive, Preventive, *Personalized*, and Participatory

The goal of systems biology is to fundamentally transform the practice of medicine, and ISB researchers have taken the leadership role in catalyzing this transformation. We are developing tools and techniques, and pursuing research that will usher in a new era of predictive, preventive, personalized and participatory medicine.

Today's medicine is reactive: we wait until someone is sick before administering treatment. Medicine of the future will be predictive and preventive, examining the unique biology of an individual to assess their probability of developing various diseases and then designing appropriate treatments, even before the onset of a disease. Today's medicine is also myopic: we use only a few measurements to diagnose disease and are generally unable to make fine distinctions between individuals or between subtle variations of the same disease. Medicine of the future will use more sophisticated measurements, as well as more measurements overall, thereby yielding accurate health assessments for truly personalized treatments.

Improved personal measurements and personalized treatments are the keys to improving health care. Diseases arise from either genetic abnormalities, detrimental environmental factors, (poor diet, infectious organisms, or toxins), or a combination of these. We know certain genetic patterns can make a person unusually susceptible to factors in their environment. We also know certain defective genes will increase the probability of an individual having certain health problems. For example, a woman with a single copy of the mutant breast cancer 1 gene (BRCA-1) has a 70 percent chance of developing breast cancer by the time she's 60 years old. Unfortunately, today there is no practical way for each of us to determine our genetic makeup and, more important, to understand the likely health consequences. However, in the future individuals will be able to easily obtain such information, and then work closely with their health practitioner to develop a predictive, preventive and personalized health-care program.

Prediction. The technologies and tools of systems biology will provide medical practitioners with two exciting sources of health-related diagnostic data: By examining an individual's complete genetic makeup, a physician will be able to generate comprehensive predictions about the patient's health prospects. And by examining protein markers which naturally occur in an individual's blood, a physician will be able to accurately determine a person's health status, including both the current effects of any abnormal genes and the current reactions to any environmental toxins or infectious pathogens.

Prevention. The new approach to medicine, based on each individual's genetic makeup, will help us determine the probability of an individual contracting certain diseases, as well as reveal how an individual may respond to various treatments, thereby providing guidance for developing customized therapeutic drugs. Thus another use of the technologies and tools of systems biology will be to develop preventive treatments for individuals, based on their potential health problems, as indicated by their genetic makeup and current blood- protein markers.

The goal of this new approach to medicine will be to use the most fundamental health-related information — an individual's genetic makeup plus current health status (as

identified by blood protein markers) — to prescribe appropriate preventive drugs. For example, given your genetic makeup, you may have a 40% chance of developing breast cancer by age 50, but if you start taking a certain drug at age 35, that chance could drop to 5% at age 50.

In fact, scientists at ISB are currently involved in several research programs involving blood diagnosis of complex diseases, including type I diabetes, breast cancer, and prostate cancer. Cancer is the second leading cause of death in the United States, with prostate cancer accounting for one third of all cancer cases among men, and breast cancer accounting for approximately half of all cancer cases among women. ISB scientists are currently researching protein markers which occur in blood to better identify the onset, metastatic potential, and probable course of these cancers in individuals, with the eventual goal of developing more effective treatments.

The common theme running through all of this research and its application to medicine -- the predictive and preventive potential of systems biology -- is **personalization**. On average, each human differs from another by *less than one percent* of their genetic makeup. But these genetic differences give rise to our physical differences, including our potential predisposition to various diseases. So the ability to examine each individual's unique genetic makeup and thereby customize our approaches to medical treatment is at the heart of this new era of predictive, preventive, personalized medicine.

As a result of this personalization, medicine will become **participatory**. Patients will actively participate in personal choices about illness and well-being. Participatory medicine will require the development of powerful new approaches for securely handling enormous amounts of personal information and for educating both patients and their physicians.