SCIENTISTS & RESEARCH

FACULTY

SENIOR RESEARCH SCIENTISTS

AFFILIATE FACULTY

RESEARCH

AREAS OF FOCUS
P4 Medicine
Sustainable Environment

P4 Medicine

P4 Medicine at a Glance

- P4 medicine is predictive, preventive, personalized and participatory.
- P4 medicine is the clinical face of systems medicine.
- P4 medicine promises to provide deep insights into disease mechanisms.
- P4 medicine will make blood a diagnostic window for viewing health and disease for the individual.
- P4 medicine will allow for the stratification of complex diseases into distinct subtypes for an impedance match against proper drugs.
- P4 medicine will provide new approaches to drug target discovery.
- P4 medicine will shift focus from reactive medicine to wellness.
- P4 medicine will drive profound economic, policy and social changes.

P4 Medicine Explained

Systems biology will revolutionize the practice of healthcare in the coming decades. Today, medicine is largely reactive. It waits until a person is sick and then treats a disease, with varying levels of success. The revolution will emerge from the convergence of systems biology and the digital revolution's ability to create consumer devices, generate and analyze "big data" sets and deploy this information through business and social networks.

Systems medicine is based on the idea that disease results from the perturbation of a biological system or network by a genetic mutation or by a pathological environmental factor, such as a bacteria, toxin or carcinogen. The network perturbation causes a dynamic change in the system that leads to the expression of altered information (e.g. mRNA or proteins) and these in turn encode the pathophysiology of the disease. This view of disease could lead to a profoundly different approach to medicine, one that is predictive, preventive, personalized, and participatory -- what we have called P4 medicine. It also promotes systems approaches to diagnosis, therapy and prevention.

By providing an understanding of disease at the molecular level, systems medicine will eventually be able to ***predict*** when an organ will become diseased or when a perturbation in a biological network could progress to disease. Alterations in biological networks can be reflected in the structure, quantity, or location of the proteins making up those networks. For example, IBS researchers have been developing tests that can flag the presence of particular cancers by detecting proteins in the blood, allowing those cancers to be treated at an early stage. As more such tests are developed, the proteins in

"P4 Medicine has two major objectives: to quantify wellness and to demystify disease."

–Lee Hood, MD, PhD
President and Co-founder, Institute for Systems Biology

Related Links

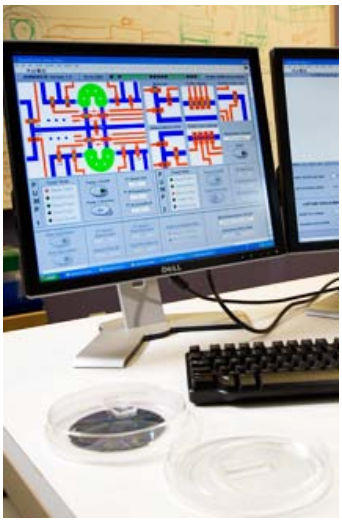
Watch to Lee Hood's TEDxRAINIER talk on P4 medicine.

Watch Lee Hood's lecture on P4 medicine to doctors at Inova Fairfax Hospital in Falls Church, Virginia.

The P4 Medicine institute (P4Mi) was created to advance P4 medicine and serve as a link between the lab and clinic.

Why Systems Biology

When biological networks are disrupted by disease, they typically produce proteins not seen under healthy conditions. The identification of these biomarkers would allow diseases to be detected and treated much earlier than is possible today. This research could revolutionize cancer management by providing markers for cancer risk, early detection, prognosis, and therapeutic response. Many such biomarkers could be measured in a single blood sample, providing a fast and easy screen for a wide range of medical conditions.



Why Use Blood as a Window

Nanotechnology and microfluidics devices exist that can measure 50 organ-specific blood proteins from each of the 50 organs in just five minutes using only a fraction of a droplet of blood.

blood could reveal the health status of every major organ in the body, enabling detailed predictions of disease causation and progression.

A systems view of disease also can provide the understanding needed to ***prevent*** biological systems from entering into disease states. The nodes within a network that control the overall behavior of the network can be identified, and drugs can be developed to channel networks into healthy states and away from disease states. Medical treatments then would consist of the therapeutic perturbation of biological networks. For example, if a person has an 80 percent change of developing prostate cancer at 50, taking preventive drugs beginning at age 35 could reduce the probability of disease to 2 percent. That would be a true preventive drug.

The ability to predict and prevent disease will in turn make it possible to ***personalize*** medicine. Within a few years, it will be possible to sequence an individual's genome for less than a thousand dollars. The DNA differences between individuals contribute to not only their unique physical characteristics but also to their differing susceptibility to disease. Medicine will be able to take into account how these DNA differences -- along with each person's environmental exposures and experiences -- influence an individual's biological systems. The result will be personalized predictions of disease and personalized treatments to prevent disease.

Finally, medicine will become ***participatory*** because patients will be in a position to take more responsibility for charting and participating in their own health care. Many predictions of future health status will be probabilistic because of random processes occurring in biological systems and in the interactions between biological systems and environmental factors. People will need to understand the nature of these processes and interactions to make good health choices. Physicians and other health care professionals will need to understand how to communicate this information to patients and how to take full advantage of P4 medicine.

Societal Dimensions of P4 Medicine

Realizing the promise of P4 medicine will require -- and will drive -- profound economic, policy, and social changes.

P4 medicine has the potential to transform virtually every sector of the health care industry. Prediction and prevention of disease will shift the basis of medicine to monitoring and safeguarding health. Personalized treatments will challenge physicians and pharmaceutical companies to deliver drugs optimized to each individual. Participatory medicine will require changes in the education of patients and physicians to encompass P4 concepts. For example, current medical school curricula do not include P4 medicine, which physicians will need to practice 21st century medicine.

P4 medicine also will require new standards and new policies for handling biological and health care information about individuals. Genomes may contain information that people wish to keep private, and predictions of future health status raise complex questions about how much people want to know or want their insurance companies to know. Complex data sets will need to be handled securely and interpreted knowledgeably and thoroughly.

The advent of P4 medicine will require that new kinds of relationships be established among academia, government, and industry. A point of failure in the past has been the transfer of new ideas and technologies from a research laboratory into the marketplace. Often, new ideas and technologies need to be developed to a proof of principle stage before they are ready to be commercialized. New institutional arrangements and partnerships will be necessary to take advantage of scientific and technological innovations, analyze the economic and social drivers that are important for commercialization, and help formulate policies that will make changes acceptable to the stakeholders in the health care system. These steps will be especially important as the costs of traditional health care continue to rise and as the potential of P4 medicine becomes apparent.

P4 medicine has a number of interesting implications. First, the development of systems approaches together with pioneering new technologies (individual genome sequencing, measurement of thousands of blood proteins from a fraction of a droplet of blood) and new computational and mathematical tools will lead to a digitalization of medicine. Namely, the ability to obtain disease-relevant information from single molecules, single cells or single individuals. This will lead within 10 years to billions of data points for each individual patient. How one reduces this enormous data dimensionality to simple hypotheses about health and disease is one of the grand challenges of computational medicine.

Second, systems approaches to disease, together with new systems approaches to diagnosis, therapy and prevention will eventually lead to a focus on wellness (rather than disease) and in the future a sharp break in the ever escalating costs of medicine. P4 medicine will eventually deliver health care at rates that will permit us to export P4 medicine to the developing world —and this will in turn lead to the democratization of health care. Thus P4 medicine will become the very foundation of global medicine.

Third, P4 medicine will necessitate a fundamental change in the business plans of virtually every sector of the health care industry over the next 10 years. This will provide challenges to existing companies and opportunities to create new companies specialized in the needs of P4 medicine.