

Systems Biology, Transforming Technologies and the Emergence of P4 Medicine (Predictive, Personalized, Preventive and Participatory)

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The challenge for biology in the 21st century is the need to deal with its incredible complexity. One powerful way to think of biology is to view it as an informational science. This view leads to the conclusion that biological information is captured, mined, integrated and finally executed by biological networks. Hence the challenge in understanding biological complexity is that of deciphering the operation of dynamic biological networks across the three time scales of life—evolution, development and physiological responses. Systems approaches to biology are focused on delineating and deciphering dynamic biological networks. I will outline the contemporary state of systems biology and then focus on its application to disease. In particular I will discuss in detail a model system we have studied—prion disease in mice. This systems approach provides a powerful new approach to understanding disease mechanisms—and suggests new strategies for diagnosis and therapy. I will discuss in some detail our systems approach to blood diagnostics. Then I will then focus on a series of emerging technologies that will transform the landscape of medicine—next generation DNA sequencing, new approaches to protein analysis, single cell analyses and the powerful new applications of molecular imaging techniques. It appears that a systems approach to disease, together with these emerging technologies, as well as the development of powerful new computational and mathematical tools will transform medicine over the next 5-20 years from its currently reactive state to a mode that is predictive, personalized, preventive and participatory (P4 medicine).