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 by biological networks and finally passed off to molecular machines for execution. 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 and their interactions with simple and complex molecular machines. I will discuss the principles and infrastructure needed for systems biology.

I will then focus on our efforts at a systems approach to disease—looking at a neurodegenerative (prion) disease and glioblastoma in mice. We published a few years ago a study on prion disease that has taken more than 5 years that integrates 6 different types of data and lays out the principles of a systems approach to disease including dealing with the striking signal to noise problems of high throughput biological measurements and biology itself (e.g. polymorphisms). One interesting question that I will discuss is how close the murine model diseases mimic their human counterparts. From these studies comes a clear understanding of some of the principal opportunities systems biology brings to medicine and the study of disease.

Then I will discuss the emerging technologies that will transform biology and medicine over the next 10 years—many of which include minaturization and parallelization, e.g., next generation DNA sequencing, targeted mass spectrometry, microfluidic protein chips, new approaches to protein-capture agents, single-cell analyses, single protein molecule analyses and the use of induced pluripotential cells to understand development and stratify disease. Many of these assays are being developed as clinical assays—and some of these will be discussed.

Finally, I will focus on a new computational approach to examining cell-type-specific gene expression in the brain. This new approach opens up exciting new possibilities of understanding brain organization and function.

It appears that systems medicine, together with emerging technologies and 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). I will describe the nature of P4 medicine, its implications for the individual and its societal implications for healthcare. I will also take about strategic partnerships that the Institute for Systems Biology has developed to bring P4 medicine to patients. Finally, I will comment on the fundamental nature of the big science/small science clash in biology (and medicine) and point a path toward a future resolution of this conflict.