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The Next Level: Applying Genomic Science to Patient Management

To understand the concept of systems biology is to understand health and disease at a cellular, tissue, organ, and organ system level. One of the true pioneers of approaching the practice of medicine using systems biology is Dr. Leroy Hood. Dr. Hood is credited with developing a philosophy called P4 medicine: health care that is predictive, preventive, personalized, and participatory. A contemporary and one-time classmate of Dr. James Fries, who was interviewed in the April issue, Dr. Hood has had an extraordinary career that now spans five decades and has taken him from classrooms at Caltech and Johns Hopkins, to a Bill Gates-funded laboratory at the University of Washington, to an impressive assortment of biotech companies, and finally to a nonprofit organization he founded and now leads, the Institute for Systems Biology (ISB) in Seattle, Washington. ISB is in the process of beginning one of the most ambitious longitudinal studies ever designed: the 100K Wellness Project. The initial pilot study will expand in phases, with the ultimate goal being 100,000 subjects monitored over 25 years.

Clinician/Researcher of the Month

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Dr. Leroy Hood is considered a true visionary whose areas of expertise range from medicine to biochemistry to engineering. Alongside colleagues at the California Institute of Technology—where he earned his undergraduate degree and his PhD, and where he held a faculty position for 22 years—he developed the DNA gene sequencer and synthesizer and the protein synthesizer and sequencer in the 1980s, two key pieces of equipment that heralded the genomic age in which we live today. He has been a pillar in the field of biotechnology and played a role in founding more than 14 companies, including Amgen, Rosetta Inpharmatics, Integrated Diagnostics, and the Accelerator. Dr. Hood was one of the original twelve scientists invited to discuss and design the Human Genome Project.

In 2000, Dr. Hood founded a nonprofit organization, the Institute for Systems Biology, in Seattle, Washington, with the goal of pioneering a holistic and global approach to studying biological problems. Dr. Hood describes the concept of a systems biology approach to medicine as having two central features:

- In the future every individual patient will have a virtual cloud of billions of data points of many different types of data (molecular, and cellular, and genetic, and organ, and higher level phenotypic data, and even social network data). These data all needed to be seamlessly integrated together and dimensionality reduced to be able to create models that allowed us to optimize wellness and minimize disease for the individual.
- The reflections of disease are embedded in what we call the network of networks. That is, there are networks that operate at the genetic level, at the molecular level, at the cellular level, at the organ level, at the individual level, and these networks, in an integrated manner, handle the information of life. If you can capture changes in disease-perturbed networks, you gain deep insights into disease mechanisms and have new strategies for doing both diagnostic and therapeutic approaches to the disease.

Systems medicine, as Dr. Hood explains, is currently at a tipping point. DNA sequencing is entering its third generation, and the cost of sequencing continues to fall (expectations are that a genome test will cost just $100 and take 15 minutes—the equivalent of a simple medical test—in the next 5 to 8 years). Dr. Hood and his colleagues have been studying disease progression and underlying biological networks. Thus far, they have looked at neurodegenerative diseases, cancer, and liver toxicity from this perspective. Most recently, the ISB team has applied a systems approach to blood diagnostics by creating a panel of 13 blood proteins that provide the ability to distinguish benign lung nodules from their neoplastic counterparts.

This year, ISB has begun a large pilot project involving the longitudinal, Framingham-like study of a hundred thousand well patients. Many measurements will be tracked over a period of 20 to 30 years with the expectation that individuals will eventually divide into two categories: there will be a set of patients that remain well and perhaps get even healthier, and there will be another set of patients that over time will transition from wellness to disease. The study has commenced with 100 initial subjects (the “Pioneer 100”), and Dr. Bland is enrolled as a study participant.

Dr. Hood describes this study as having multiple, actionable opportunities:

- To create a data cloud for each of the individuals, which, when analyzed, will optimize wellness and minimize disease.
- To take the data from those individuals who remain well and mine it for metrics of wellness.
- To see transitions from wellness to disease in the hundred thousand for virtually all major diseases, and to look at these early disease mechanisms at early diagnosis and try to begin attempting early diversion back to a wellness trajectory.

Dr. Bland and Dr. Hood discuss his extraordinary visions for medicine, technology, and the future of health care. Dr. Hood describes the major influences—and obstacles—in his life, his education, and his career, and he provides his insights as to how our society can encourage and nurture future scientists and visionaries.

References

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