2. HEALTH AND WELLBEING

Introduction

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PART 2 OF THIS BOOK EXPLORES the remarkable progress and challenges we are seeing in the most intimate and personal of our sciences, the one with the most immediate impact on all of us across the planet: the science of health and medicine.

The first article sets the scene. Gillam et al. describe the progress of medical science over human history and make a strong case for a convergence of technologies that will change the face of healthcare within our lifetime. The remaining articles shed light on the convergent strands that make up this larger picture, by focusing on particular medical science challenges and the technologies being developed to overcome them.

Any assertion that the coming healthcare revolution will be universal is credible only if we can demonstrate how it can cross the economic and social divides of the modern world. Robertson et al. show that a combination of globally pervasive cell phone technology and the computational technique of Bayesian networks can enable collection of computerized healthcare records in regions where medical care is sparse and can also provide automated, accurate diagnoses.

An understanding of the human brain is one of the grand challenges of medicine, and Lichtman et al. describe their approach to the generation of the vast datasets needed to understand this most

complex of structures. Even imaging the human brain at the subcellular level, with its estimated 160 trillion synaptic connections, is a challenge that will test the bounds of data storage, and that is merely the first step in deducing function from form.

An approach to the next stage of understanding how we think is presented by Horvitz and Kristan, who describe techniques for recording sequences of neuronal activity and correlating them with behavior in the simplest of organisms. This work will lead to a new generation of software tools, bringing techniques of machine learning/artificial intelligence to generate new insights into medical data.

While the sets of data that make up a personal medical record are orders of magnitude smaller than those describing the architecture of the brain, current trends toward universal electronic healthcare records mean that a large proportion of the global population will soon have records of their health available in a digital form. This will constitute in aggregate a dataset of a size and complexity rivaling those of neuroscience. Here we find parallel challenges and opportunities. Buchan, Winn, and Bishop apply novel machine learning techniques to this vast body of healthcare data to automate the selection of therapies that have the most desirable outcome. Technologies such as these will be needed if we are to realize the world of the "Healthcare Singularity," in which the collective experience of human healthcare is used to inform clinical best practice at the speed of computation.

While the coming era of computerized health records promises more accessible and more detailed medical data, the usability of this information will require the adoption of standard forms of encoding so that inferences can be made across datasets. Cardelli and Priami look toward a future in which medical data can be overlaid onto executable models that encode the underlying logic of biological systems—to not only depict the behavior of an organism but also predict its future condition or reaction to a stimulus. In the case of neuroscience, such models may help us understand how we think; in the case of medical records, they may help us understand the mechanisms of disease and treatment. Although the computational modeling of biological phenomena is in its infancy, it provides perhaps the most intriguing insights into the emerging complementary and synergistic relationship between computational and living systems.