Foreword

Health and biomedicine are in the midst of revolutionary change. Health care, mental health, and public health are converging as discovery science reveals these traditional "silos" share biologic pathways and collaborative management demonstrates better outcomes. Health care reimbursement is increasingly framed in terms of paying for outcomes achieved through value-based purchasing and population health management. Individuals are more engaged in their health and wellness decisions, using personal biomedical monitoring devices and testing services and engaging in citizen science. Systems biology is revealing the complex interactions among a person's genome, microbiome, immune system, neurologic system, social factors, and environment. Novel biomarkers and therapeutics exploit these interactions.

These advances are fueled by digitization and generation of data at an unprecedented scale. The volume of health care data has multiplied 8 times since 2013 and is projected to grow at a compound annual rate of 36% between 2018 and 2025[1]. The rate of growth of biomedical research data is comparable[2]. When you consider recent estimates that socioeconomics, health behaviors, and environment—factors outside of the domain of health care and biomedicine—contribute as much as 80% to health outcomes[3], the variety and scale of health-related data are breathtaking.

Biomedical informatics provides the scientific basis for making sense of these data—methods and tools to structure, mine, visualize, and reason with data and information. Biomedical informatics also provides the scientific basis for incorporating data and information into effective workflows—techniques to link people, process, and technology into systems; methods to evaluate systems and technology components; and methods to facilitate system-level change.

Biomedical informatics grew out of efforts to understand biomedical reasoning[4], such as artificial intelligence; to develop medical systems, such as multiphasic screening[5]; and to write computer programs to solve clinical problems, such as diagnosis and treatment of acid-base disorders[6]. By the late 1970s, "medical informatics" was used interchangeably with "computer applications in medical care". As computer programs were written for various allied health disciplines, nursing informatics, dental informatics, and public health informatics emerged. The 1980s saw the emergence of computational biology for applications such as scientific visualization and bioinformatics to support tasks such as DNA sequence analysis.

Biomedical Informatics: Computer Applications in Health Care and Biomedicine provided the first comprehensive guide to the field with its first edition in 1990. That edition and the subsequent three have served as the core syllabus for introductory courses in informatics and as a reference source for those seeking advanced training or working in the field. The fifth edition carries on the tradition with new topics, comprehensive glossary, reading lists, and citations.

I encourage people who are considering formal education in biomedical informatics to use this book to sample the field. The book's framework provides a guide for educators from junior high to graduate school as they design introductory courses in biomedical informatics. It is the basic text for students entering the field.

With digitization and data driving change across the health and biomedicine ecosystem, everyone in the ecosystem will benefit from reading *Biomedical Informatics* and using it as a handbook to guide their work. The following is a sample of questions readers can turn to the book to explore:

- **Practicing health professionals**—How do I recognize an information need? How do I quickly scan and filter information to answer a question? How do I sense the fitness of the information to answer my question? How do I configure my electronic health record to focus my attention and save time? How do I recognize when to override decision support? How do I analyze data from my practice to identify learning and improvement opportunities? How do I engage with patients outside of face-to-face encounters?
- **Quality improvement teams**—How might we detect if the outcome we are trying to improve is changing in the desired direction? Are data available in our operational systems that are fit for that purpose? What combination of pattern detection algorithm, workflow process, decision support, and training might work together to change the outcome? How can we adapt operational processes and systems to test the change and to scale if it proves effective?
- **Discovery science teams**—How do data about biological systems differ from data about physical systems? How do we decide when to use integrative analytic approaches and when to use reductionist approaches? How much context do we need to keep about data we create and how do we structure the metadata? How do we optimize compute and storage platforms? How might we leverage electronic health record-derived phenotype to generate hypotheses?
- **Artificial intelligence researchers or health "app" developers**—What health outcome am I trying to change? Do I need a detection, prediction, or classification algorithm? What sources of data might be fit for that purpose? What type of intervention might change the outcome? Who would be the best target for the intervention? What is the best place in their workflow to incorporate the intervention?
- **Health system leaders**—How do we restructure team roles and electronic health record workflows to reduce clinician burnout and improve care quality? How do we take advantage of technology-enabled self-management and virtual visits to increase adherence and close gaps in care? How do we continuously evaluate evidence and implement or de-implement guidelines and decision support across our system? How do we leverage technology to deploy context-sensitive just-in-time learning across our system?
- **Health policy makers**—How might we enhance health information privacy and security and reduce barriers to using data for population

health, health care quality improvement, and discovery? To what degree is de-identification a safeguard? What combination of legislative mandate, executive action, and industry-driven innovation will accelerate health data interoperability and business agility? How might federal and state governments enable communities to access small area data to inform their collective action to improve community health and well-being?

You have taken the first step in exploring these frontiers by picking up this book. Enjoy!

References

1. IDC White Paper, The Digitization of the World from Edge to Core, #US44413318 November 2018 ► https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf
2. Vamathevan, J. V., Apweiler, R., & Birney, W. (2019). Biomedical data resources: Bioinformatics infrastructure for biomedical data science. *Annual Review of Biomedical Data Science*, *2*:199–222.
3. County Health Rankings Program and Roadmap ► https://www.countyhealthrankings.org/explore-health-rankings/measures-data-sources/county-health-rankings-model
4. Ledley, R., & Lusted, L. (1959). Reasoning foundations of medical diagnosis. *Science*, *130*, 9–21.
5. Collen, M. F. (1966). Periodic health examinations using an automated multitest laboratory. *JAMA*, *195*, 830–3.
6. Bleich, H. L. (1971). The computer as a consultant. *New England Journal of Medicine*, *284*, 141–7.

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