

# Computational Medicine in Data Mining and Modeling



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Editors

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 Springer

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# Preface

Humans have been exploring the ways to heal wounds and sicknesses since times we evolved as a species and started to form social structures. The earliest of these efforts date back to prehistoric times and are, thus, older than literacy itself. Most of the information regarding the techniques that were used in those times comes from careful examinations of human remains and the artifacts that have been found. Evidence shows that men used three forms of medical treatment – herbs, surgery, and clay and earth – all used either externally with bandages for wounds or through oral ingestion. The effects of different substances and the proper ways of applying them had likely been found through trial and error. Furthermore, it is likely that any form of medical treatment was accompanied by a magical or spiritual interpretation.

The earliest written accounts of medical practice date back to around 3300 BC and have been created in ancient Egypt. Techniques that had been known at the time included setting of broken bones and several forms of open surgery; an elaborate set of different drugs was also known. Evidence also shows that the ancient Egyptians were in fact able to distinguish between different medical conditions and have introduced the basic approach to medicine, which includes a medical examination, diagnoses, and prognoses (much the same it is done to this day). Furthermore, there seems to be a sense of specialization among the medical practitioners, at least according to the ancient Greek historian Herodotus, who is quoted as saying that the practice of medicine is so specialized among them that each physician is a healer of one disease and no more. Medical institutions, referred to as Houses of Life, are known to have been established in ancient Egypt as early as the First Dynasty.

The ancient Egyptian medicine heavily influenced later medical practices in ancient Greece and Rome. The Greeks have left extensive written traces of their medical practices. A towering figure in the history of medicine was the Greek physician Hippocrates of Kos. He is widely considered to be the “father of modern medicine” and has invented the famous Oath of Hippocrates, which still serves as the fundamental ethical norm in medicine. Together with his students, Hippocrates began the practice of categorizing illnesses as acute, chronic, endemic, and epidemic. Two things can be observed from this: first, the approach to medicine was

taking up a scholarly form, with groups of masters and students studying different medical conditions, and second, a systematic approach was taken. These observations lead to the conclusion that medicine had been established as a scientific field.

In parallel with the developments in ancient Greece and, later, Rome, the practice of medicine has also evolved in India and China. According to the sacred text of Charaka, based on the Hindu beliefs, health and disease are not predetermined and life may be influenced by human effort. Medicine was divided into eight branches: internal medicine, surgery and anatomy, pediatrics, toxicology, spirit medicine, aphrodisiacs, science of rejuvenation, and eye, ear, nose, and throat diseases. The healthcare system involved an elaborate education structure, in which the process of training a physician took seven years. Chinese medicine, in addition to herbal treatments and surgical operations, also introduced the practices of acupuncture and massages.

During the Islamic Golden Age, spanning from the eighth to the fifteenth century, scientific developments had been centered in the Middle East and driven by Islamic scholars. Central to the medical developments at that time was the Islamic belief that Allah had sent a cure for every ailment and that it was the duty of Muslims to take care of the body and spirit. In essence, this meant that the cures had been made accessible to men, allowing for an active and relatively secular development of medical science. Islamic scholars also gathered as much of the already acquired knowledge as they could, both from the Greek and Roman sources, as well as the East. A sophisticated healthcare system was established, built around public hospitals. Furthermore, physicians kept detailed records of their practices. These data were used both for spreading and developing knowledge, as well as could be provided for peer review in case a physician was accused of malpractice. During the Islamic Golden Age, medical research went beyond looking at the symptoms of an illness and finding the means to alleviate them, to establishing the very cause of the disease.

The sixteenth century brought the Renaissance to Europe and with it a revival of interest in science and knowledge. One of the central focuses of that age was the “man” and the human body, leading to large leaps in the understanding of anatomy and the human functions. Much of the research that was done was descriptive in nature and relied heavily on postmortem examinations and autopsies. The development of modern neurology began at this time, as well as the efforts to understand and describe the pulmonary and circulatory systems. Pharmacological foundations were adopted from the Islamic medicine, and significantly expanded, with the use of minerals and chemicals as remedies, which included drugs like opium and quinine. Major centers of medical science were situated in Italy, in Padua and Bologna.

During the nineteenth century, the practice of medicine underwent significant changes with rapid advances in science, as well as new approaches by physicians, and gave rise to modern medicine. Medical practitioners began to perform much more systematic analyses of patients’ symptoms in diagnosis. Anesthesia and aseptic operating theaters were introduced for surgeries. Theory regarding

microorganisms being the cause of different diseases was introduced and later accepted. As for the means of medical research, these times saw major advances in chemical and laboratory equipment and techniques. Another big breakthrough was brought on by the development of statistical methods in epidemiology. Finally, psychiatry had been established as a separate field. This rate of progress continued well into the twentieth century, when it was also influenced by the two World Wars and the needs they had brought forward.

The twenty-first century has witnessed the sequencing of the entire human genome in 2003, and the subsequent developments in the genetic and proteomic sequencing technologies, following which we can study medical conditions and biological processes down to a very fine grain level. The body of information is further reinforced by precise imaging and laboratory analyses. On the other hand, following Moore's law for more than 40 years has yielded immensely powerful computing systems. Putting the two together points to an opportunity to study and treat illnesses with the support of highly accurate computational models and an opportunity to explore, *in silico*, how a certain patient may respond to a certain treatment. At the same time, the introduction of digital medical records paved the way for large-scale epidemiological analyses. Such information could lead to the discovery of complex and well-hidden rules in the functions and interactions of biological systems.

This book aims to deliver a high-level overview of different mathematical and computational techniques that are currently being employed in order to further the body of knowledge in the medical domain. The book chooses to go wide rather than deep in the sense that the readers will only be presented the flavors, ideas, and potentials of different techniques that are or can be used, rather than giving them a definitive tutorial on any of these techniques. The authors hope that with such an approach, the book might serve as an inspiration for future multidisciplinary research and help to establish a better understanding of the opportunities that lie ahead.

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