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Kazem Sadegh-Zadeh

Handbook of Analytic Philosophy of Medicine

Second Edition

Revised and Enlarged

(120 Figures, 63 Tables)

Springer

Kazem Sadegh-Zadeh
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To

Maria, David, and Manuel

Foreword

This work will shape the philosophy of medicine for years to come. There are very few scholarly endeavors that truly encompass a field while also having the promise of shaping and changing that field. Kazem Sadegh-Zadeh has produced such a volume for the philosophy of medicine. This is a foundational work of amazing depth and scope, which is also user-friendly. No one engaged in the philosophy of medicine will in the future be able to proceed, save in the light of and in response to the analyses, arguments, and reflections Sadegh-Zadeh has compassed in this extraordinarily rich and important study. He has succeeded in bringing together in an integrated vision an exploration of the epistemological, practical, and logical frameworks that sustain the engagement of physicians, as well as define the place of patients in medicine. This opus magnum provides remarkably careful explorations of the concept of disease, as well as of the diagnosis and treatment of patients in the acts of medical knowing and treatment. It situates the intertwining of diagnoses, the appreciation of therapy warrants, and the engagement of physicians in treating patients within the complex phenomenon of medicine. This work even has what is tantamount to an appendix that shows the bearing of logic on medicine.

The work begins with a careful exploration of the language of medicine, attending to its epistemic impact, its syntax, semantics, and pragmatics, including the various ways in which medical concepts are framed and engaged. Sadegh-Zadeh then examines medicine's encounter with the patient as a biopscho-social reality caught up in the drama of health, illness, and disease. In this study of medical practice, Sadegh-Zadeh creatively attends to the interaction of patient and physician in clinical practice. His analysis of the interconnection of anamnesis, diagnosis, prognosis, therapy, and prevention in the clinical context is innovative, displaying a remarkable depth of understanding that constitutes not just a foundational contribution to the literature, but a reframing of the field. It offers a comprehensive perspective, which is a tour de force. Drawing on a nuanced and subtle appreciation of epistemology in general and an account of the character of medicine in particular, Sadegh-

Zadeh explores the semantics and pragmatics of medical knowledge. He then relates these reflections to the intertwining of moral concerns, the character of logic in medicine, and a consideration of medical ontology within which, among other things, he provides a careful analysis of medical reality and the character of medical truth. He ties all of this to what can only be described as a powerful vision of the conceptual fundamentals that constitute the scope of the philosophy of medicine. Sadegh-Zadeh offers what will without doubt for the foreseeable future be the most widely influential and comprehensive account of the philosophy of medicine.

This impressively nuanced work bears the mark of a lifetime of research, reflections, and publications on the philosophy of medicine. While others were engaged in the birth of bioethics, Sadegh-Zadeh was focusing with critical energy on the philosophy of medicine. As a result, he became one of the central figures driving the re-emergence of the philosophy of medicine as a scholarly field. Early on, he helped to establish and then expand the scope and depth of philosophical medicine. One must note in particular that he aided in supporting scholarship in the philosophy of medicine through his pioneering work with his journal *Metamed* which was established in 1977, and which then later took the name *Metamedicine* and which finally became *Theoretical Medicine*. He has also been involved from the early years in *The Journal of Medicine and Philosophy*. Both through his own scholarly articles, as well as through creating vehicles for the publication of scholarly articles, his work in the philosophy of medicine has helped locate bioethics within the broader geography of the foundational explanation and therapeutic concerns that define medicine. As a physician and philosopher, Sadegh-Zadeh has without flinching addressed the conceptually challenging issues that lie at the basis of a philosophical appreciation of contemporary medicine. The result is that Kazem Sadegh-Zadeh has come to have a command of the philosophy of medicine possessed by no other scholar.

Drawing on a rich lifetime of scholarship, Sadegh-Zadeh has been able to integrate recent work in epistemology, the philosophy of science, and logic in a work in the philosophy of medicine. Because of his disciplined and innovative eye, this volume sheds a bright analytic light on the character of contemporary medicine and charts the future of the philosophy of medicine. It is marked both by creativity and an encyclopedic scope, and will establish itself as the standard for the field. It is likely that no one could have accomplished such a substantial exploration of the nature of medicine, other than Kazem Sadegh-Zadeh. He has produced an indispensable resource for scholars in the philosophy of medicine, including those working in bioethics. This work surely secures Kazem Sadegh-Zadeh's place as a cardinal founder of the contemporary field of the philosophy of medicine.

Houston, TX
April 23, 2011

H. Tristram Engelhardt, Jr.
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Preface to the Second Edition

This is a book for those who understand it, or are willing to do so, but not for those who don't understand it. So, reviews and public comments by members of the latter category are unwelcome. The volume is a carefully revised and considerably enlarged new edition. Type-setting errors and other bugs have been corrected and three flawed figures have been redrawn. Other changes made include some stylistic amendments and the following additions and expansions, which have increased the number of parts from VIII to IX, of chapters from 30 to 34, of figures by 4, of tables by 2, and of pages by 91:

Added:

- Sections 3.4–3.5: The Pragmatic Impact of Medical Language + The Communal Origin of Medical Language (pp. 58–59),
- Chapter 4: Medical Linguistics (pp. 61–68),
- Subsection 17.4.4: Probabilistic Networks (pp. 626–627),
- Part VI: Medical Artificial Intelligence (pp. 709–743).

Expanded:

- Subsubsection “Free will”: (pp. 156–162),
- Section 9.1.2: Dynamic, Branching Clinical Questionnaires (301–312),
- Section 17.3: Modal Logics in Medicine (pp. 614–619),
- Subsection 17.5.4: Fuzzy Logic in Biomedicine (pp. 665–683),
- Section 24.3: Misdiagnoses (pp. 821–826),
- Chapter 27: Perspectivism (pp. 875–884),
- Subsection 33.1.5: Bayes's Theorem (pp. 1050–1053),
- Subsection 34.2.4: Degrees of Fuzziness and Clarity (pp. 1079–1083),
- Section 34.5: Summary (pp. 1114–1120).

Tecklenburg,
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October 15, 2013

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Preface to the First Edition

Medicine is a science and practice of intervention, manipulation, and control concerned with curing sick people, caring for sick people, preventing maladies, and promoting health. What necessitates this task, is the human suffering that results from maladies, and the desire for remedy and relief. Medicine serves this human need by attempting to lessen suffering that human beings evaluate as *bad*, and to restore and augment well-being that human beings evaluate as *good*. On this account, medicine as health care is *practiced morality* insofar as it acts against what is bad, and promotes what is good, for human beings. And insofar as it seeks rules of action toward achieving those goals and strives continually to improve the quality and efficacy of these rules, i.e., as clinical research, it belongs to *normative ethics*. Medicine is not human biology, biophysics, biochemistry, or biopathology. Nor is it any sum of these and similar biomedical and natural sciences. To view it as such, would shift medicine toward bio- and anthropotechnology where morality and ethics would lose their meaning and significance. As an aid in preventing such an autolysis of medicine, the present book elucidates and advances the view sketched above by:

- analyzing the structure of medical language, knowledge, and theories,
- inquiring into the foundations of the clinical encounter,
- introducing the logic and methodology of clinical decision-making,
- suggesting comprehensive theories of organism, life, and psyche; of health, illness, and disease; and of etiology, diagnosis, prognosis, prevention, and therapy,
- investigating the moral and metaphysical issues central to medical practice and research.

To this end, the book offers in its final Part IX, as an appendix so to speak, a concise introduction to some focal systems and methods of logic that are needed and used throughout. Each line, paragraph, and page of its remaining eight parts relies upon what precedes it and what has been said in Part IX.

The readers, therefore, should study the book systematically following the instructions given in Figure 1 on page 9. In that case, it will prove absolutely self-contained. It does not require any special knowledge and is easily accessible to all interested students. By virtue of its didactic style, the book is also usable in graduate courses in the philosophy of medicine, bioethics, medical ethics, philosophy, medical artificial intelligence, and clinical decision-making.

My thanks are due to H. Tristram Engelhardt, Jr., from whom I have learned, among many other things, that the concept of disease *says what ought not to be* (Engelhardt, 1975, 127). It is thus a deontic concept (from the Greek *δέον*, *deon*, for “what is binding”, “duty”) which obliges us to act. Since this normative aspect is dismissed by most physicians and philosophers of medicine alike, initially I wanted to analyze and demonstrate it in what eventually became the present handbook, HAPM, by means of deontic logic. In the process of writing, however, my thoughts extended beyond the concept of disease to the entire field of medicine when I fully recognized the deonticity of the field as a whole in the early 1980s (Sadegh-Zadeh, 1983). Although it is a fascinating feature of medicine that places the institution of health care in the same category as charity, it seems to have been overlooked by philosophers of medicine and medical ethicists until now. I hope they will concern themselves with this issue and discover additional facts about it when they read HAPM.

Also, my intellectual debt is to four scholars whose works greatly impacted my way of thinking and my life: Karl Eduard Rothschuh (1908–1984), one of my teachers at the University of Münster in Germany, ignited my love for the philosophy of medicine in 1964 when I was a graduate student of medicine and philosophy; Patrick Suppes’s precision in philosophizing taught me analytic philosophy in the late 1960s; Newton C.A. da Costa’s paraconsistent logic changed my view of logic and my *Weltanschauung* in the late 1970s; and Lotfi A. Zadeh’s fuzzy logic changed everything anew and inspired me to initiate fuzzy analytic philosophy and methodology of medicine in the early 1980s.

I am particularly grateful to my wife, Maria, for surrounding me with so much love and support over the long period of creating HAPM; and to my sons, David and Manuel, for their assistance. Manuel drew the figures. David did extensive L^AT_EX work (references, indexes) and produced, with the aid of Matlab[®], the 3D representation of high blood pressure on page 696.

I would also like to extend special thanks to the editors of the *Philosophy and Medicine* for including HAPM in their highly respectable book series, and for excellent supervision, advice, and support; to Mr. Richard Preville in Charlotte, North Carolina, for carefully transforming my imperfect ‘German English’ into well-readable English; and to Springer for their outstanding production process management. But without the patient and competent work of three anonymous reviewers, none of us would be reading this line right now. I wholeheartedly thank all of them for their thoughtful comments and valuable suggestions.

Some of the ideas in this handbook present a further development of their seeds and preliminary forms that have appeared in my previous publications.

Specifically, my theories of health and disease in Section 7.3, of etiology in Section 7.5, and of diagnosis in Section 9.2 are based on my “Fundamentals of clinical methodology”, 1-4, in *Artificial Intelligence in Medicine* (1994-2000); on my theory of fuzzy health, illness, and disease in *The Journal of Medicine and Philosophy* (2000, 2008); and on my “The logic of diagnosis” in *Handbook of the Philosophy of Science*, Vol. 16 (2011). Section 17.5.4 relies on my previous articles “Fuzzy genomes” and “The fuzzy polynucleotide space revisited” in *Artificial Intelligence in Medicine* (2000, 2007). Although during the process of writing the handbook, I have drawn on this previously published work, most of this material has been substantially revised, rewritten, and supplemented.

One of the reviewers proposed that I create a companion website for HAPM, which could provide a glossary and additional resources online. I welcomed the proposal, as I have already been offering a website on philosophy of medicine in German for many years. This website has now been internationalized to facilitate studies in the analytic philosophy of medicine, including HAPM. You may take a look at it here $\Rightarrow$ <http://www.philmed-online.net>

Tecklenburg,
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Summer 2010

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Introduction

In a pain there is always more knowledge about the truth than in all wise men's serenity. All I know I have learned from the unfortunates, and what I recognized I saw through the look of the pained (Stefan Zweig, 1922, [1993] 56, translated by the present author).

0.1 A Fresh Start

I invite readers to look with me at medical practice and research to identify their philosophical, methodological, and logical problems with the purpose of trying to understand what is going on in health and patient care and to find out how to enhance their quality. Let me explain:

Errors of diagnosis and treatment are major problems in health care, despite recent advances in biomedical and clinical sciences and technology. They are due to physician fallibility, on the one hand; and medical imperfection, on the other, raising the question of how the failures emerge and whether it is possible to prevent them. To evaluate this question and to understand its far-reaching implications, we may first consider the following five examples:¹

1. A 42-year-old female teacher consulted her family physician because of diarrhea that had lasted for five days. The doctor diagnosed enteritis and administered antibiotics. The patient died the next week. An autopsy revealed that she had a stomach cancer.

2. A 49-year-old male physiologist had been suffering from some malaise for several weeks. Based on his own expert knowledge, he convinced himself that he had exocrine pancreatic insufficiency, i.e., lowered production of digestive enzymes by pancreas. He visited an internist to have his suspicion examined. The doctor took some blood tests. A few days later, she calmed the patient down assuring him he did not have an exocrine pancreatic insufficiency. Since his health didn't improve, in the years that followed he successively consulted five additional doctors, to receive additional, conflicting diagnoses. It was only the last, sixth, doctor who was able to confirm his own, initial suspicion of suffering from exocrine pancreatic insufficiency, and to help him.

3. A 56-year-old housewife complained of being poisoned by her neighbors, and was hospitalized in a psychiatric institution. Paranoid schizophrenia was

¹ The examples 2 and 3 are real patient histories encountered by the author himself. The other three are based on (Cutler, 1998).

diagnosed. In the third year of her hospital life, a new, young doctor at the ward discovered that the patient had cancer of the esophagus. He concluded the cancer had certainly existed, at least as a precancer, prior to the patient's hospitalization three years earlier, and had caused her gastro-esophageal distress that she had interpreted as a symptom of being poisoned by her neighbors. But it was now too late to correct the past. She died shortly after the diagnosis was made.

4. A 22-year-old female student was diagnosed of having multiple sclerosis because of her complaints of permanent, unbearable headaches, and of some sensory and muscular problems. She was treated for multiple sclerosis over the next eight years. After she moved to another city and changed her apartment, her health problems disappeared immediately. No further treatment was needed. She was able to continue her university studies. Her new doctor speculated that effluents from the furniture in her previous apartment might have been the cause of her health problems.

5. A 39-year-old male engineer had several episodes of sharp, stabbing left chest pain. The pain lasted only a few minutes each time, did not radiate, and was not related to physical activity. The physician whom he visited, found that his ECG was normal and all blood parameters, including blood lipids, were also normal. No risk factors were present. The patient had no history of any disease. X-rays of thoracic organs displayed no abnormalities. The doctor diagnosed Tietze's syndrome and sent the patient home, assuring him that he had no serious health problem. He was asked to return in six weeks. Two weeks later the physician read his obituary notice in the local newspaper. He had not survived a second heart attack.

There are still many more misdiagnoses, wrong treatments, and physician-caused misfortunes, pains, and deaths. *Why and how do they arise?* I have tried to understand this phenomenon since the beginning of my clinical training in 1968. Living in West Berlin then, i.e., the free sector of then divided Berlin, Germany, I regularly witnessed at clinical rounds the debates between our chief and senior officers about their conflicting bedside diagnoses and treatment recommendations. It was surprising and even disturbing to me as a young physician to encounter such differences among their clinical judgments. This observation made me aware of an issue for the first time that our teachers had not taught us during our medical education, i.e., methods of clinical reasoning. Clinical reasoning, also called clinical decision-making, diagnostic-therapeutic decision-making, clinical judgment, and clinical cognition, lies at the heart of clinical practice and thus medicine. Although as students of medicine we had learned large parts of natural sciences such as chemistry, physics, and biology; of biomedical sciences such as anatomy, physiology, biochemistry, pathology, and pathophysiology; and many clinical disciplines, diseases, therapies, and disease-specific methods of diagnosing and treating individual diseases such as gastritis, leukemia, schizophrenia, etc., we had learned nothing about how to search for a diagnosis and treatment *in general*, i.e., how to arrive at a clinical judgment. I asked myself whether there was a scientific methodology of

clinical judgment that our teachers had withheld from us, and if so, what did it look like? My extensive search was disappointing. It revealed that there was no such methodology. I have since been concerned with this topic, and have found that a variety of highly intriguing linguistic, logical, methodological, mathematical, epistemological, moral, and metaphysical issues and problems are involved. The present book addresses these issues and problems, many of which have either been overlooked or neglected until now by both medicine and its philosophers. Their analysis will not only enrich medical practice, research, and philosophy, but may also stimulate interest in the other areas involved.

0.2 The Objective

Medicine constitutes one of the major and most influential social institutions, including religion, law, education, and government, that interpret, rule, and shape our lives. It is therefore desirable to examine the adequacy and quality of its methods, means, practices, and perspectives. The present book undertakes such an examination by inquiring into the structure, nature, and goals of medicine. Our aim is to clarify the conceptual, methodological, epistemological, moral, logical, and metaphysical foundations of medicine in order to understand what occurs in the doctor-patient clinical encounter; what factors, forces, and sciences determine the dynamics and products of this interaction system; and how to best organize it.

0.3 The Subject

To attain our above-mentioned goals, we shall do analytic philosophy of medicine. But what is analytic philosophy of medicine?

Analytic philosophy that has emerged at the turn of the 20th century, is a well-established method of philosophical inquiry by means of logical and conceptual analysis. It was founded by the German mathematician and logician Gottlob Frege (1848–1925), and the British mathematician and logician Bertrand Russell (1872–1970).² It attempts to clarify the structure and meaning of concepts, conceptual systems, knowledge, and action, and to analyze and improve methods of scientific investigation and reasoning. Accordingly,

² It is sometimes maintained in the literature that analytic philosophy was founded by the British philosopher George Edward Moore (1873–1958) and the Austrian-British philosopher Ludwig Wittgenstein (1889–1951). However, it began earlier in Friedrich Ludwig Gottlob Frege's works on the philosophy of mathematics and language (Frege, 1884, 1891, 1892a, 1892b, 1893, 1904; Kenny, 2000; Beaney, 2013a), which caused Bertrand Arthur William Russell to change his neo-Hegelian perspective (Russell, 1969) and initiate the logical phase of his philosophical inquiries as of 1900 (Russell, 1903, 1905, 1914, 1919; Whitehead and Russell, 1910).

analytic philosophy of medicine is philosophy of medicine by means of logical and conceptual analysis (Sadegh-Zadeh, 1970a–c, 1977c).

My basic motive for analyzing medicine logically is my long-standing interest in the sources and conundrums of physician fallibility and medical imperfection; my desire to contribute to enhanced physician performance; and my conviction that such enhancement is feasible by employing logic in medicine. A measure of physician performance is provided by the quality of diagnostic-therapeutic decisions. Since these decisions are obvious outcomes of clinical reasoning, their quality mirrors the quality of that reasoning. It is well known, however, that despite the advances in medical science and technology, many clinical decisions turn out wrong, leading to malpractice suits. As some statistic report, there are 30–38% misdiagnoses (Gross and Löffler, 1997; Sadegh-Zadeh, 1981c). At first glance, these errors call into question the clinical competence of the physicians involved. Viewed from a practical perspective, this deficiency in physician performance may appear as a failure that in principle is avoidable by improving the diagnostic-therapeutic methodology, say for example, using ‘medical expert systems’. However, there are also scholars who interpret it as an inevitable physician fallibility due to the peculiarity of clinical practice as “a science of particulars” (Gorovitz and MacIntyre, 1976).

I have been systematically concerned with the issues surrounding clinical reasoning and its imperfection since about 1970. In the present book, some results of this endeavor are discussed. They reveal the deeply philosophical-metaphysical character of medicine, the realization of which is likely to exert far-reaching impacts on both medicine and philosophy of medicine. The discovery that was briefly mentioned on page X in the Preface to the First Edition, represents one of them. That is, (i) medicine as health care consists of obligatory well-doings and avoiding prohibited wrong-doings, and is thus *practiced morality*; and (ii) as clinical research, it seeks, justifies, and establishes rules of that practice, and thus, belongs to *normative ethics* (Sadegh-Zadeh, 1983). In contrast to the philosophically and methodologically sterile debate about whether medicine is a science or an art (Montgomery, 2006; Munson, 1981), the above thesis asserts that medicine is a duty-driven and normative, i.e. deontic, discipline. (The adjective “deontic” originates from the Greek term *δέον*, *deon*, for “what is binding”, “duty”.) I am confident that philosophers of medicine as well as medical professionals will welcome this surprising finding. As we shall see later, its recognition and understanding requires minutely detailed logical analyses of medical language, concepts, knowledge, and decisions. The logic primer provided in the final part of the book is meant to make such illuminating analyses possible. Apart from its philosophical-metaphysical fertility, the finding will also stimulate medical informaticians and expert system researchers to customize their clinical decision-support systems and hospital information systems accordingly, and to base them on deontic logic. (For deontic logic, see Section 31.2 on page 997.)

The book is divided into nine parts, Parts I–IX, comprising 34 chapters. The starting-point is *the patient*, examined in Part II, since the philosophy of

medicine that I shall develop will be tailored to her/his needs and interests. To this end, in the opening Part I preceding it (pp. 13–118), the language of medicine is carefully studied. It is shown at the outset why the choice of a particular language has effects on the knowledge that is expressed by using its vocabulary. This motivates us to thoroughly consider the syntax and semantics of medical language and the problems caused by the ambiguity and vagueness of its terms. The pragmatic aspects of medical language are analyzed to show its deep embeddedness in the social sphere. Also a brief introduction is given to what is called medical linguistics in medical informatics and information sciences, including medical vocabularies, terminologies, and coding systems. Most important for medicine and its philosophy and methodology is the subsequent analysis of the varieties of medical concepts (qualitative, comparative, quantitative, dispositional, classical, non-classical, etc.) and the comprehensive introduction to methods of scientific concept formation in the closing chapter of this Part I.

Part II focuses on medical praxiology, i.e., the theory of medical practice (pp. 121–398). To this end, the patient is interpreted as a bio-psycho-social and moral agent in order to propose a theory of organism, an emergentist theory of psyche, and a concept of sociosomatics that substitutes for psychosomatics. This interpretation will help to provide an understanding of what it means to say that such an agent may feel ill, or be categorized as diseased. In the pursuit of this understanding, the concepts of health, illness, disease, diagnosis, prognosis, therapy, and prevention are logically analyzed, and a number of novel conceptual frameworks are advanced. These include *the prototype resemblance theory of disease*, according to which a few prototype diseases determine, by similarity relationships, the whole category of diseases; a *probabilistic theory of etiology*, which reconstructs medical causality as probabilistic-causal associations between cause and effect; and a *theory of relativity of clinical judgment*, according to which diagnostic-therapeutic decisions and preventive measures are relative to a number of parameters. The aim is to inquire into how medicine is engaged in shaping the human world, by deciding who is a patient to be subjected to diagnostics and therapy, and who is a non-patient. In this way, nosology, pathology, etiology, diagnostics, prognostics, therapy, and prevention are understood as conceptual and methodological endeavors that serve as means of medical worldmaking. All necessary logical tools are provided in our logic primer in Part IX.

Part III is devoted to medical knowledge (pp. 401–572). In it, we analyze the concept and types of medical knowledge to expose the relationships of this knowledge to what it talks about. It is shown that medical knowledge consists of norms, hypotheses, and theories. While mainly for syntactic reasons medical norms and most types of medical hypotheses are not verifiable, theories are empirically not testable at all because, like norms, they do not consist of statements of facts. They are conceptual structures, just like buildings are architectural structures. Several sample theories are reconstructed according to this *non-statement view* of theories, to discuss its medical-epistemological

consequences. An important question in this context is from where medical theories and knowledge arise. It is shown that, in contrast to our received views, the primary sources of medical knowledge and theories are medical-scientific communities and not individual scientists. Pronouncements such as “The German physician and bacteriologist Robert Koch discovered the bacillus of tuberculosis” are inappropriate because underlying such a discovery are groups of interacting scientists and technical assistants, research funding agencies, and a number of social and political-historical factors. This social-constructivist idea was first developed by Ludwik Fleck and adopted later by Thomas Kuhn. It is of particular significance in medicine because it implies that, by and large, medical-scientific communities determine the nature of medical truth and the way how to act. We even go one step further to suggest a theory of *technoconstructivism*, according to which empirical-scientific research today is in transition to engineering; and empirical-scientific knowledge is increasingly being constructed as a technical product and commodity by technology.

In Part IV (pp. 575–603), the concept of medical deontics is introduced to include under this umbrella term all medical research, on the one hand, whose outcome is formulated by deontic sentences, namely ought-to-do rules; and all health-care practices that obey such deontic rules, on the other. Thus, medical deontics not only covers normative medical ethics and law, but also diagnostic-therapeutic research as well as clinical practice. This momentous *deonticity* of medicine also includes the concept of disease, that is argued to be a deontic concept created by common morality in the human society. As was already pointed out above, the deontic character of medicine has been ignored until now. I hope that philosophers of medicine, and medical ethicists as well, will concern themselves with this intriguing feature of health care in order to open new fields of research and to enlarge our understanding of how maladies and healing practices and professions are intertwined with morality and charity.

Part V (pp. 607–706) deals with the roles that systems of logic play *in* medicine, and with the question whether there is an inherent logic *of* medicine. It is shown that, due to the syntactic richness of medical language, different types of logic are required to cope with it in medical research and practice, because it transcends the scope and capabilities of individual logic systems. In this plurality of logics in medicine, an exception is provided by fuzzy logic. Fuzzy logic, also briefly introduced in our logic primer in the final Part IX (pp. 891–1120), is a logic of vagueness, and therefore highly suitable for use in medicine. It is a general enough logic to satisfy almost all logical needs of medicine, and moreover, to serve as an outstanding methodological tool for constructing innovative techniques of problem-solving in research and practice. This has been demonstrated by an extensive application of fuzzy logic to clinical, biomedical, conceptual, medical-deontic, and metaphysical issues. By virtue of its wide applicability, strength, and elegance, it is likely to become the leading logic in medicine in the not-too-distant future. Besides the

logical pluralism referred to above, no other logical peculiarity of medicine is observed that would require a specific *medical logic*. However, that does not mean that there is no *rationale* behind medical thinking and acting.

In Part VI (pp. 709–743), a brief sketch is given of what has come to be known as *artificial intelligence in medicine*, ‘AI in medicine’ or ‘AIM’ for short. The aim is to analyze the foundations of this new field of research and practice in medicine to understand the major role the innovative technology of artificial intelligence currently plays, and will in the future play, in health care. To this end, the origin of AI in medicine is traced to provide some insights into the development of ‘medical decision-making’ as a scholarly field of inquiry in close relationship with the emergence of electronic computers around 1950. It is shown why and how AI in medicine branched from medical decision-making. The evolution and prospects of the discipline are outlined to prepare the critical discussion of its impact on the healing relationship and health care in Section 25.7, *Quo Vadis Medicina?*, on pages 845–852.

Medical metaphysics is the subject of Part VII (pp. 747–852). It is primarily concerned with medical ontology, medical truth, and the nature of medicine:

(i) The basic science *ontology* is divided into pure ontology, applied ontology, and formal ontology which are thoroughly discussed. In these three areas, novel suggestions have been put forward by using fuzzy logic. Specifically, we have introduced a fuzzy ontology that seems to be auspicious for both medicine and philosophy. It not only determines degrees of being by means of a fuzzy existence operator, that we have dubbed the *Heraclitean operator*, but also makes it possible to construct a fuzzy mereology, by means of which vague part-whole relationships become tractable. Of particular importance is our distinction between *de re* and *de dicto* ontology, that is based on a syntactic criterion, and enables differentiation between fictional entities such as Sherlock Holmes, and real ones. The salient advantage of this approach is that it allows precise analyses of controversial questions like “are diseases fictitious or real?”. Using this approach, we have extensively examined the ontological problems associated with nosology, psychiatry, and psychosomatics, and have also critically explored the so-called biomedical ontology engineering that is expanding in medical information sciences today.

(ii) Regarding medical truth, it has been shown that there is sufficient evidence to support the assertion that medical truths are system-relative, and are formed within the respective health care systems themselves. They do not mirror or report scientifically discovered facts ‘in the world out there’ which could be independent of the conceptual system from where they are viewed and judged. This problem not only concerns truth in medical sciences (p. 819 ff.), but also truth in clinical practice. Specifically, the concept of misdiagnosis has been precisely defined that enables us to discern the system relativity of misdiagnoses and to identify their causes (p. 821 ff.).

(iii) Particular emphasis has been placed on the analysis of medicine as a scientific field. Abandoning widespread, exclusive mono-categorizations such

as “medicine is a science” versus “medicine is an art”, we have demonstrated that in declarations of the type “medicine is such and such”, the global term “medicine” should be differentiated to recognize that medicine, comprising many heterogeneous disciplines, belongs to a large number of categories. For example, without doubt biomedicine is natural science; clinical research, however, is practical science; it is also normative ethics; clinical practice is practiced morality; and so on. What is worth noting, is that medicine is also a *poietic* science (from the Greek term *ποίησις*, “poiesis”, for *making, creating*) that invents, designs, and produces medical devices in the widest sense of the term “making”, from drugs to prosthetics to brain chips to artificial organs to artificial babies. Medicine is thus on its way to become an engineering science, conducted as health engineering and anthropotechnology.

Part VIII of the book, an *Epilog* (pp. 855–888), attempts to clarify some epistemological and metaphysical issues that our preceding analyses of medicine have revealed. First, taking into account the peculiarities of medicine, the concept of science is explicated to demonstrate why the traditional understanding of this concept in the general philosophy of science is terribly one-sided. The yield is a tripartite concept of science that, in contrast to the traditional mono-scientism, suggests three different types of science: theoretical science, practical science, and deontic science. Medicine comprises all three types of science. Second, it is shown that rationality cannot be a criterion of the scientificity of medicine, because rationality is something relative, and depends on the perspective from which it is judged. Third, it is argued that this dependence on perspective is an inescapable property of judgments, rendering *perspectivism* an interesting approach to the philosophy of world-views, including epistemology and ontology both in medicine and elsewhere.

To conduct the studies sketched above, we must first assemble the logical and conceptual tools that we shall use in the book. This task is accomplished in Part IX as a sort of Appendix (pp. 891–1120). It provides the logical fundamentals comprising an outline of the relevant systems of logic from classical set theory and logic, to modal logics, non-classical logics and probability logic, and further on to fuzzy set theory and logic. For readers not acquainted with logic and its terminology, Part IX is the prerequisite for understanding the medical-philosophical frameworks and theories developed in the book.

0.4 Methods of Inquiry

It is a truism that a tool for analyzing a particular object should be sufficiently sensitive to the subtleties of that object. Otherwise, the details and peculiarities of the analysandum will be lost. For example, it would be fatuous if someone tried to examine a biological cell by employing a pneumatic hammer, since such a brute-force approach only destroys the cell. The ingenious apparatus of a microscope and thin light waves will be necessary to discern what is before one’s eyes. The same holds for analyzing a scientific enterprise

itself. Medicine as a scientific enterprise is too complex an area to be amenable to coarse, crude, confused, or anarchic tools and techniques of inquiry.

My interest in the subject addressed in this book goes back to my youth when, in the early 1960s, I was a graduate student of medicine and philosophy at the University of Münster in Germany. Initially, I was an adherent to phenomenologic and hermeneutic approaches, until analytic philosophy persuaded me in the late 1960s that it was a more adequate and superior method of philosophical analysis in medicine. I had the good fortune to realize early on that in philosophizing on topics such as diagnostic-therapeutic reasoning or the conceptual structures of medical knowledge, hypotheses and theories, well-developed, sensitive, and precise tools and techniques such as logic are required. The reason why logic is needed rather than a pneumatic hammer for such an inquiry, is simply that both diagnostic-therapeutic reasoning and epistemic entities and structures have some logical characteristics, which are not discernible and adequately analyzable by tools other than logic. Accordingly, my approach to philosophy of medicine in this book takes an analytic route. It is my conviction that medicine will only benefit from logical self-analysis.

0.5 How to Read this Book

The subject of the book outlined in Section 0.3 above requires the application of a number of different logics. As a consequence of using logic as our method of inquiry, the book is not light reading like a traditional medical-philosophical treatise. Some knowledge of logic is necessary for understanding the analyses,

Fig. 1. How to read this book

reconstructions, and constructions involved. Since it would be unrealistic to suppose that every reader is acquainted with all the 15 logics used in the book, or to require that she study 15 separate logic primers of about 200 pages each before studying the present book, a concise and easily digestible introduction to their essentials is provided in the final part of the book that she may consult before or while reading chapters of the book. In that case, the book will be absolutely self-contained and easily accessible to any interested student. The author recommends that you study the logic primer in Part IX first, and then proceed sequentially through Parts I–VIII and not skip anything. The book has been organized systematically and should be read accordingly (see Figure 1).

An important note: It is worth emphasizing at the outset that whenever and wherever we speak of “scientific knowledge” in this book, we mean *empirical-scientific*, including medical, knowledge. Unless specified otherwise, we never mean *formal-scientific*, i.e., mathematical or logical, knowledge which may be analytically true or false, but has nothing to do with experiential states of affairs ‘in the world out there’.