Preface

The following work aims at introducing a new approach to medicine – namely from the vantage point of information science, systems biology and biophysics. As far as I know, this is the first dissertation at the Medical University of Vienna that deals with such considerations.

I firmly believe that such an approach is both necessary and rewarding. My intention is to describe some basic aspects of a theoretical framework for what will become - in my view - the next generation of medical diagnosis and therapy. The underlying idea is based on the notion that medicine can be regarded as an information science - and in my view it should be regarded as such. I think that it will turn out quite fruitful to apply engineering concepts to medicine: First, recognizing the `biological programs´ that underly human development and life both in health and in disease, will lead to new diagnostic and therapeutic approaches e.g. in cancer and in degenerative diseases. Second, creating `engineered´ biological programs offers the potential to introduce elements of `responsiveness´, `feed-back´ and `learning´ into new therapeutic approaches.

I have placed these new ideas into a broad historical perspective to show that these concepts are a natural extension of the development of medicine, the latter being increasingly influenced by the natural sciences and by engineering. A discussion of medical ethics makes clear that besides all engineering considerations, the `art of medicine´ always goes along with ideas from the humanities, which invariably accompany all `medical acting´.

A large part of this work deals with aspects of `information´ in medicine and in biology, as well as in engineering. Biological information processing is compared to analogous processes in electronic circuits, and some of the basic mathematical and physical concepts that are available for describing biological systems and that help understand how biological information processing works, are presented.

Eventually, potential applications of these concepts in medical diagnosis and treatment are mentioned, together with a discussion of ethical problems. Some conceivable examples of potential new diagnostic and therapeutic approaches will provide evidence that the `information science and systems approach´ to medicine offers considerable potential benefit that could not be achieved by conventional approaches.

This work contains somewhat more mathematical and physical formulas and ideas, and concepts from engineering science than usual medical dissertations. Besides the fact that this is inevitable given the topic of this work, it also reflects my personal enjoyment of these subjects. Mathematics is often called the “language” of natural sciences, and I am strongly convinced that the use of quantitative methods in medicine and biology is both necessary and very helpful (Fagerström T.ör. et al., 1996; Cohen JE, 2004).

Nobody would doubt that quantitative data is important when it comes to dosages of medical therapies e.g. chemotherapy in oncology, digitalis in cardiology, antibiotics in infectious diseases, hormones in endocrinology, and drug dosages in many other types of pharmacotherapy (Goodman LS & Gilman A, 2001). The same holds true for molecular

interactions in cellular signal transduction networks that are currently being unraveled. A profound and rigorous understanding of molecular mechanisms will require biophysical and mathematical models that e.g. permit predictions and that are necessary for establishing potentially highly effective, novel future therapies.

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Remark: On September 23 2003, Harvard Medical School announced to set up a department devoted to “systems biology” – the first entirely new department founded at the institution in 20 years (Check E, 2003). The aim of the new department is – according to Marc Kirschner, the chief of the new department – to `create a community of people whose main interest is in bringing quantitative mathematical approaches to complex systems´ e.g. to integrate computer modeling, large-scale data analysis and biological experimentation, thus applying expertise from mathematical and physical sciences to biological problems (ibid.).