

Preface

*Society is well governed when its people obey the magistrates,
and the magistrates obey the law.*

Solon

I cannot teach anybody anything. I can only make them think.

Socrates

Science is the creator of prosperity.

Plato

*Freedom is the sure possession of those alone who have the
courage to defend it.*

Pericles

*Wealth consists not in having great possessions, but in having
few wants.*

Epicurus

The aim of this book is to provide a comprehensive conceptual account of the five fundamental elements of life and society, viz., energy, information, feedback, adaptation, and self-organization. These elements inherently support any living organism, human society, or man-made system.

Energy is the cornerstone of everything. *Information* is included in the “program” (organized plan) of any living organism, to function over time, which is implemented by the DNA that encodes the genes and is transferred from generation to generation. It is one of the main factors of the progress of modern society which is characterized as the “*information society*”. *Feedback* (control) is a “must” for any kind of system, biological, natural, or technological, to be stable and operate according to its purpose. *Adaptation* is the capability of living organisms, species, and societies to adapt to changes that occur in their environment so as to fit to it. It

is the principle that lies behind the natural selection and evolution. *Self-organization* has many interpretations, the predominant of which is the “tendency” of natural systems to become more organized by their own, and shows more structure or order or pattern without the help or intervention of any external agent. This means that spontaneous emergence of global complex structure occurs out of local interactions.

All the above aspects of life and society have been of principal concern to humans over time, and a plethora of concepts and scientific or technological methodologies were developed and studied. The topics addressed in this book are the subject matter in a vast number of sources in the literature and the web. The book gives a collective and cohesive presentation of the fundamental issues, concepts, principles, and methods drawn from the literature, including modern applications and short historical notes of each field. The presentation is kept at a level sufficient for a clear understanding of the concepts and principles by the general scientific reader. In many cases, viz., thermodynamics, communication systems, information theory, and feedback control, the discussion includes the basic mathematical analysis aspects in some more detail which are deemed to be necessary and useful for the nonprofessionals. Unavoidably, the material provided in the book does not exhaust all the results and views available in the literature. However, it is considered to be over sufficient for disseminating the fundamental concepts and issues. The views and opinions/quotations on the delicate aspects of life and society, presented in the book, are those coined and published by the referenced authors. No attempt was made to modify or speculate them in any way.

The writing of this book was inspired by the need of a concise, cohesive, and complete presentation of the five life-and-society fundamental elements (pillars): energy, information, feedback, adaptation, and self-organization in a unique volume. Surely, besides the general reader, this book will be valuable as a source for introductory or complementary material in relevant science and engineering academic programs.

The book involves 13 chapters. Chapter 1 provides an introduction to the book presenting the background concepts of life and society, and outlining the five fundamental elements of life and society considered in the book.

Chapters 2 and 3 are devoted to the *energy*. Chapter 2 presents the basic issues of energy (historical landmarks, types, sources, and environmental impact), and Chap. 3 is devoted to thermodynamics (basic concepts, laws of thermodynamics, entropy, exergy, branches of thermodynamics, and entropy interpretations).

Chapters 4 and 5 are concerned with the *information* element. Chapter 4 introduces the concept of information and reviews the communication systems and information theory. Chapter 5 discusses information science, information technology, and information systems in enterprises and organizations.

Chapters 6 and 7 are devoted to the *feedback element*. Chapter 6 presents the concept of feedback and control, the history of its study, and the methods for linear and nonlinear control systems analysis and design developed between about 1935 and 1950 (classical control). Chapter 7 reviews the modern control techniques which are based on the state-space model, namely, Lyapunov stability,

state-feedback (eigenvalue/model matching) control, and optimal control (deterministic and stochastic). The classes of adaptive, predictive, robust, nonlinear, and intelligent control are also discussed.

Chapter 8 is concerned with the *adaptation* in biology and society including the related scientific fields of complexity and complex adaptive systems.

Chapter 9 is devoted to the final fundamental element studied in the book, i.e., the *self-organization* of natural and societal systems. The four self-organization mechanisms observed in nature are first reviewed, and the concept of self-organized criticality (edge of chaos) is then discussed. The role of *cybernetics* in the study of self-organization is also examined.

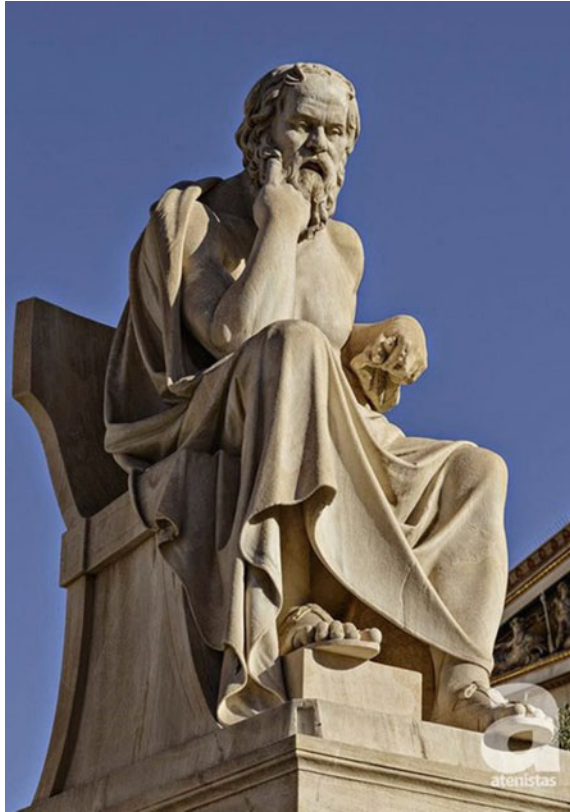
Chapters 10 through 13 are concerned with the role and impact of the five fundamental elements studied in the book on life and society discussing major issues and a variety of examples. Chapter 10 discusses the fundamental role that energy plays in life and society, starting with an examination of the three basic biochemical pathways of energy in life (photosynthesis, respiration, and metabolism) and going to the energy flow in ecosystems. The evolution of energy resources, the thermoeconomy, and the saving of energy in the human society are then investigated.

Chapter 11 deals with a number of issues that refer to the role of information in life and society. These include the substantive and transmission roles of information in biology, and the information technology applications in modern society, such as office automation, power generation /distribution, computer-assisted manufacturing, robotics, business/e-commerce, education, medicine, and transportation.

Chapter 12 reviews the role and impact of feedback in both living organisms and societal systems. Representative examples that best show the operation of negative and positive feedback in biology and society are provided. These include temperature, water, sugar, and hydrogen ion (pH) regulation, autocatalytic (autoreproduction) reactions, enzyme operation, cardiovascular–respiratory system, process control, manufacturing control, air flight and traffic control, robot control, management control, and economic control systems.

Finally, Chap. 13 provides a number of adaptation and self-organization examples and applications in life and society. These examples are adaptations of animals, ecosystems, climate change, immune systems, social–ecological systems, capital /stock market, general society system, knowledge management, and man-made self-organizing systems.

In overall, the book provides a cohesive and complete picture of the five fundamental elements: energy, information, feedback, adaptation, and self-organization, and the role they play in sustained life and society, including selected modern applications.



Only one thing I know, that I know nothing.

Only Absolute Truth is that there are No Absolute Truths.

Socrates, Athens, 470-399 B.C.

Footnote: *Statue of Socrates in front of Athens Academy*

(Sculptor: Leonidas Droses/1885. Photographer: Elias Georgouleas/2014, “atenistas”:

www.athenssculptures.com).

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Energy, Information, Feedback, Adaptation, and
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The Fundamental Elements of Life and Society

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