

# The Four Laws That Do Not Drive The Universe

Elements of Thermodynamics  
for the Curious and Intelligent

Arieh Ben-Naim

# The Four Laws **That Do Not Drive** The Universe

Elements of Thermodynamics for the Curious and Intelligent

This book provides a clear and mystery-free presentation of the central concepts in thermodynamics — probability, entropy, Helmholtz energy and Gibbs energy. It presents the concepts of entropy, free energy and various formulations of the Second Law in a friendly, simple language. It is devoid of all kinds of fancy and pompous statements made by authors of popular science books who write on this subject.

The book focuses on the Four Laws of Thermodynamics. As it is said in the dedication page, this book is addressed to readers who might have already been exposed to Atkins' book having a similar title. It challenges both the title, and the contents of Atkins' book: *Four Laws That Drive The Universe*. One can glean from the title of this new book that the author's views are diametrically opposed to the views of Atkins.

The book is addressed to any curious and intelligent reader. It aims to tickle, and hopefully to satisfy your curiosity. It also aims to challenge your gray matter, and to enrich your knowledge by telling you some facts and ideas regarding the Four Laws of Thermodynamics.

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# **The Four Laws That Do Not Drive The Universe**

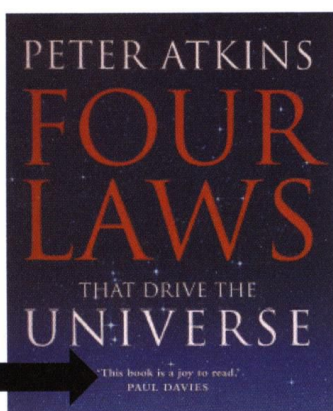
Elements of Thermodynamics  
for the Curious and Intelligent



This book is dedicated to all those who  
read or who will read Atkins's book:

**FOUR LAWS THAT DRIVE THE UNIVERSE**

This book is a joy to read  
Paul Davies



פְּתִי, יֶאֱמִין לְכָל-דְּבָר; וְעָרוֹם, יִבִּין לְאִשְׁרוֹ.  
נִחְלוּ פְּתָאִים אֲוֵלֶת; וְעָרוּמִים, יִכְתְּרוּ דַּעַת.  
משלי, יד; טו, יח





# List of Abbreviations

Av	Avogadro
FL	First Law
PD	Probability distribution
Pr	Probability
20Q	Twenty questions
SMI	Shannon's Measure of Information
SL	Second Law
TE	Thermal Equilibrium
TL	Third Law
T4L	Atkins' book "Four Laws that Drive the Universe"
ZL	Zeroth Law
Av	Avogadro



# Preface

This book is addressed to any curious and intelligent reader. The book aims to tickle, and hopefully to satisfy your curiosity. It also aims to challenge your gray matter, and to enrich your knowledge by telling you some facts and ideas regarding the Four Laws of Thermodynamics.

I am aware of the possibility that potential readers of this book might have already been exposed to Atkins' book with a similar title. Truth be told, I hope very much that you have read that book, and if you haven't, I encourage you to read it. You will be rewarded by comparing the two books.

This book challenges both the title, as well as the contents of Atkins' (2007) book, *Four Laws that Drive the Universe* (T4L). One can glean from the title of my book my diametrically opposed views from Atkins' posture. Here is how Atkins' book is described on its jacket:

*Peter Atkins explains the basis and deeper implications of each law, drawing out their precision, clarity, and beauty... the unstoppable rise of entropy explains why*

*your desk tends to get messier and why the Universe must one day die — an outcome of the iconic Second Law which C.P. Snow famously argued should be as familiar to any educated person as the works of Shakespeare.*

This is a totally misleading message to the potential reader of Atkins' book, T4L. My desk does not tend to get messier, and if it were to do so, it would have nothing to do with the Second Law. The so-called "unstoppable rise of entropy" *does not explain* anything! Also, the author does not have license to predict the death of the universe either one day or one night. I will further comment about Atkins' misleading statements throughout this book.

Although one does not need any mathematics in order to understand the elements of thermodynamics, a certain measure of mathematics is indispensable in order to derive some of the consequences of the four laws, and their applications. The level of mathematics required in thermodynamics is not particularly high, however it is within this apparently low-level of mathematics where pitfalls lie, waiting to swallow their prey. This is the main reason so many authors have shamelessly fallen into this trap.

Thus, while the book is written in a simple, friendly and non-mathematical fashion, the reader is advised to consult one of the technical books listed in the bibliography in order to understand the book's content.

I also believe that researchers and teachers of thermodynamics will benefit even more from reading this book than the lay reader who has never been exposed to thermodynamics. The reason behind this is that those who have had prior exposure to, or written textbooks, or taught thermodynamics might need to invest greater effort in “Un-learning” and disabusing themselves of the subject as it is presented in other textbooks, and “convert” to the new approach, and a new way of looking at the Four Laws of Thermodynamics.

This book is organized in five chapters. The first discusses some basic concepts used in thermodynamics. Those who are familiar with the elements of thermodynamics may skip Sections 1.1 to 1.5 of Chapter 1, and read Section 1.6 only.

The succeeding four chapters discuss the Four Laws. Each chapter starts with a brief description of the law, and then discusses the various formulations and some applications of the law. Finally, a few questions are posed which are not normally raised in textbooks on thermodynamics such as:

Is the law absolute or are there any exceptions? How does the law rank in comparison with the other laws of thermodynamics? Can we do without this law? Can we expect the law to be valid for billions of years from now, in either the past, or in the future? And finally, the intriguing question: Does the law drive anything; a simple experiment, life’s processes, or the entire universe?



I hope that you will read the book carefully and critically so that you will be able to answer these questions by yourself before moving on to read my suggested answers. In any case, any comments from you, the readers, will be welcomed.

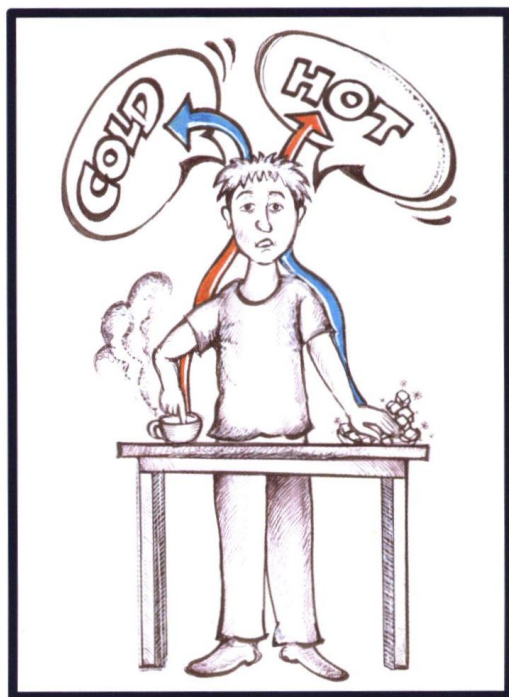
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Sensing Hot and Cold