

Contents

Chapter 1 Introduction and Historical Background

1.1	Introduction	1
1.2	The Contribution of Pasteur	1
1.2.1	Quartz	2
1.2.2	Tartaric Acid and the Tartrates	3
1.3	The Nature of the Problem	5
	References	5

Chapter 2 Theories of the Origin of Biomolecular Homochirality

2.1	Introduction	6
2.2	Chance Theories	7
2.2.1	Amplification of Tiny Stochastic Imbalances	8
2.2.2	Polymerizations Above a Critical Chain Length: Macromolecules	10
2.3	Deterministic Theories	17
	References	18

Chapter 3 The Concept of Chirality

3.1	Introduction	21
3.2	The Basic Symmetry Operations	22
3.2.1	Space Inversion: The Parity Operator, $\hat{P}$	22
3.2.2	The Time Reversion: The Time Reversal Operator, $\hat{T}$	23
3.2.3	The Charge Conjugation: The Charge Conjugation Operator, $\hat{C}$	24

The Origin of Chirality in the Molecules of Life

Albert Guijarro and Miguel Yus

© Albert Guijarro and Miguel Yus, 2009

Published by the Royal Society of Chemistry, www.rsc.org

3.3	The Failure of the Experiments of Pasteur, Curie and Others	25
3.3.1	Absence of Chiral Field	25
3.3.2	Experiments Under False Chiral Influence	25
3.3.3	Experiments Under True Chiral Influence	26
3.4	Expected Effect of True and False Chirality on Molecules	28
	References	30

Chapter 4 Chiral Physical Forces

4.1	Background	31
4.2	The Weak Interaction and the Parity Violation	31
4.2.1	The Fundamental Interactions: Gravitational, Weak Interaction, Electromagnetic and Strong Interaction	31
4.2.2	The β -Decay	34
4.2.3	Parity Violation	35
4.2.4	Unification of Forces	38
4.2.5	Quantification of the Parity Violation in Molecules: ΔE_{pv}	41
4.2.6	β -Radiolysis	46
4.3	Asymmetric Photolysis and Photosynthesis	48
4.3.1	Circularly Polarized Light: Circular Dichroism	48
4.3.2	The Magnetochiral Effect	57
4.4	Fluid Dynamics: Vortex Motion	59
	References	65

Chapter 5 Mechanisms of Amplification

5.1	Background	72
5.2	Autocatalysis	72
5.2.1	The Frank Model	72
5.2.2	Theoretical Models Derived from Frank's Original Model ⁶	75
5.2.3	Autocatalytic Amplification of the Weak Force	77
5.2.4	Asymmetric Autocatalytic Reactions	78
5.2.5	Self-replication	82
5.3	Amplification of Chirality in Other Chemical Reactions	84
5.3.1	Nonlinear Effects	84
5.3.2	Amplification of Chirality by Cooperative Forces: Growing Polymers and Supramolecular Assemblies	86
5.4	The Yamagata Cumulative Mechanism	88

5.5	The Salam Phase Transition	91
5.6	Amplification of Scalemic Compounds: Eutectic Mixtures	91
5.6.1	Solubility Properties	93
5.6.2	Sublimation Properties	97
5.7	Amplification of Chirality in Serine Octamers	98
5.7.1	Homochiral Preference and Chiral Amplification	98
5.7.2	Chemistry of Serine Octamers	99
5.7.3	Sublimation Experiments	102
	References	102
Chapter 6	Spontaneous Symmetry Breaking	
6.1	Introduction	108
6.2	Spontaneous Symmetry Breaking in Crystallization	110
	References	113
Chapter 7	Outside Earth: Meteorites and Comets	
7.1	Introduction	115
7.2	Meteorites	115
7.3	Comets	120
	References	123
Chapter 8	Other Local Deterministic Theories	
8.1	Introduction	125
8.2	Chiral Crystals and Faces on Crystals	125
8.2.1	Quartz	125
8.2.2	Calcite, Gypsum, Clay Minerals and Others	129
8.2.3	Organic Crystals: Glycine	132
8.3	Two-Dimensional Chirality	132
	References	135
Chapter 9	Intrinsic Asymmetry of the Universe: The Arrow of Space-Time and the Unequal Occurrence of Matter and Antimatter	
	References	145
	Subject Index	146