

Biological Spectroscopy

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Preface

The molecules that make up the living cell continue to excite great interest. The methods available for investigating these molecules have improved dramatically in the last decade. Some of the most powerful new techniques involve the application of electromagnetic radiation. These techniques include nuclear magnetic resonance and visible spectra, which detect transitions between energy levels, and others such as microscopy, scattering, and diffraction. In this book the term *spectroscopy* is used to cover all these methods. The close relationships among these topics are rarely emphasized in textbooks; the reading level is often either too superficial or too detailed for most readers. This book tries to bring out the recurring concepts in this field and to steer a course between the specialist text and the introductory.

Our overall aim is to lead undergraduates, graduate students, and other readers to an appreciation of the current literature. Many people find the concepts involved in spectroscopy rather difficult, so our approach here is to use worked examples and problems to emphasize important points and to illustrate biological applications rather than complex mathematical derivations. Most chapters in this text deal with one particular technique and can thus be read independently of other chapters, but we have also included a central chapter on concepts and definitions and various appendices designed to give more information on difficult points.

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Contents

Preface v

1 Introduction

The Information Available from Spectroscopy 3

2 Spectroscopy: The Study of the Interaction of Electromagnetic Radiation with Matter

What Is Electromagnetic Radiation? 7

Polarization 7

Frequency, Wavelength, Energy, and Wavenumber 9

Types of Electromagnetic Radiation 10

What Is Matter? 10

Interparticle Forces and Energies 13

Energy Levels 14

The Effect of an Applied Magnetic Field 14

Classification of Energies 15

Probing Different Energies with Different Ranges of Electromagnetic Radiation 15

Population of Energy Levels 15

The Interaction of Electromagnetic Radiation with Matter	18
Scattering	18
<i>Scattering and Interference</i>	19
<i>Scattering and Refraction</i>	21
<i>Elastic and Inelastic Scattering</i>	23
Absorption	24
<i>Transition Probabilities and Selection Rules</i>	25
<i>Absorption Depends on the Populations of Energy Levels</i>	27
<i>Absorption Spectra Depend on Concentration</i>	27
<i>The Linewidth of an Absorption Line Depends on Lifetime</i>	28
<i>Absorption Spectra Depend on the Direction of the Transition Dipole Moment</i>	29
<i>Optically Active Molecules Differentially Absorb Left- and Right-Circularly Polarized Radiation</i>	29
<i>Absorption Spectra Can Arise from the Reorientation of Magnetic Moments in a Magnetic Field</i>	30
Emission	32
<i>Fluorescence and Phosphorescence Are Two Particular Kinds of Spontaneous Emission</i>	34
Problems	35

3 Infrared Spectroscopy

37

Overview	37
Introduction	38
Experimental Parameters of an Infrared Spectrum	38
Measurements of Infrared Spectra	39
Conventional Double Beam Spectrometer	39
The Fourier Transform Method	40
Physical Basis of Infrared Spectra	41
Molecular Vibrations	41
The Morse Curve	43
Vibrational Energy Levels	43
Zero-Point Energy	44
Vibrational Energy Level Transitions	44

Polyatomic Molecules	45
Number of Vibrations	45
Vibrational Spectra of Polyatomic Molecules	45
Solvent Effects on Spectral Transitions	47
Some Biological Examples	47
Infrared Spectra of Oriented Samples	52
Correlation of the Direction of the Transition Moment of Absorption Bands with Molecular Structure	52
Polymer Spectra Can Be Complex Because of Interactions Between Electric Transition Dipoles	55
Problems	57

4 Ultraviolet and Visible Absorption Spectroscopy

61

Overview	61
Introduction	62
Parameters of Electronic Spectra	63
Electronic Energy Levels	65
Electronic Transitions: Selection Rules	66
Symmetry Considerations	66
Forbidden Transitions	66
Spin Considerations	66
The Time for an Electronic Transition	67
Absorption Range of Chromophores	69
Peptide Bonds and Amino Acids	69
Purine and Pyrimidine Bases in Nucleic Acids	70
Highly Conjugated Systems	70
Transition Metal Spectra	72
$d \rightarrow d$ Transitions	72
Charge-Transfer Spectra	72
Solvent Effects on Spectra	74
Applications of Ultraviolet Spectra to Proteins	76

Properties Associated with the Direction of the Transition Dipole Moment and Interactions Between Them	82
Linear Dichroism of Oriented Samples	82
<i>Determination of the Orientation of the Transition Dipole</i>	82
<i>Determining the Orientation of a Group</i>	83
<i>Resolving Ultraviolet Bands</i>	83
Exciton Splitting	85
Hypochromism and Hyperchromism	87
Problems	88

5 Fluorescence

91

Overview	91
Introduction	92
Physical Picture	93
Excitation and Emission Spectra	94
Transition Probability and Lifetime	95
Quantum Yield	96
Fluorescence Intensity	97
Fluorescence Polarization	98
Natural Fluorophores and Fluorescent Probes	99
Effect of Environment on Fluorescence Parameters	102
Environmental Effects on λ_{\max}	102
Environmental Effects on Quantum Yield	103
<i>Specific Quenching Processes</i>	105
Environmental Effects on Lifetimes	106
Measurements of Molecular Dynamics	107
Dynamic Quenching: The Stern-Volmer Relationship	108
Fluorescence Depolarization	110
<i>Steady-State Fluorescence Depolarization: Photoselection</i>	110
<i>Motional Depolarization</i>	110
<i>Time-Resolved Depolarization of Fluorescence Using Nanosecond Pulses</i>	112

Determination of Distances Between Chromophores by Resonance-Energy Transfer 113

Calculation of R_0 116

Fluorescent Antibodies 119

Phosphorescence 120

Problems 122

6 Nuclear Magnetic Resonance

127

Overview 127

Introduction 128

The Phenomenon 128

Magnetization 129

Measurement 130

The Spectral Parameters in NMR 133

Intensity 133

Chemical Shift 134

Spin-spin Coupling and Multiplet Structure 137

The T_2 Relaxation Time and Linewidth 139

The T_1 Relaxation Time 141

What Causes Relaxation? 142

T_1 Relaxation Processes 142

T_2 Relaxation Processes 144

The Nuclear Overhauser Effect 144

Chemical Exchange 146

Paramagnetic Centers 148

Shift and Relaxation Probes 149

Applications of NMR in Biology 150

The Assignment Problem in NMR Studies
of Macromolecules 151

Analytical Uses of NMR 156

Ligand Binding to Macromolecules 156

Ionization States and pH 159

Kinetics	162
<i>Chemical Exchange Analysis</i>	162
<i>Concentration Versus Time</i>	163
Structural Studies by NMR	164
Molecular Motion	167
<i>The Observation of Powder Spectra from Membranes</i>	169
Spatial Distribution	172
Problems	175

7 Electron Paramagnetic Resonance Spectroscopy

179

Overview	179
Introduction	180
The Resonance Condition	180
Measurement	181
Spectral Parameters	182
The Intensity	182
<i>g</i> -Value	182
Linewidths and Relaxation Times	183
Multiplet Structure in EPR Spectra	184
Hyperfine Structure	184
Spectral Anisotropy	186
Anisotropy of the <i>g</i> -Value	186
Anisotropy of the Nuclear Hyperfine Interaction <i>A</i>	189
The Time Scale for EPR	190
Different EPR Parameters May Have Different Time Scales	191
Spin Labels	193
Effect of Rate of Motion on Spin-Label Spectra	193
Anisotropic Spin-Label Motion	195
Quantitation of Amplitude of Motion: The Order Parameter	197
Lateral Diffusion in Membranes	199

Spin-Labeled Ligands Can Probe the Dimensions and Rigidity of Binding Sites	200
Spin-Label Hyperfine Splittings Are Sensitive to Polarity	202
Estimation of the Separation Between Two Paramagnetic Centers	202
Transition Metal Ions	204
Spin-Orbit Interaction: g -Values and Low Temperatures	205
Hyperfine Structure	206
Zero-Field Splitting	207
Other Applications	210
Spin Trapping	210
Problems	212

8

Scattering

217

Overview	217
Introduction	217
The Observed Scattering from an Isolated Particle That Is Small Compared with the Wavelength	218
Molecular Polarizability: The Analogy with a Weight on a Spring	219
The Wavelength Dependence of Scattering	220
The Scattering from Many Particles Whose Dimensions Are Small Compared with λ	220
Scattering from a Rigid Array	220
Solution Scattering and Information on Molecular Weight	221
Scattering from Larger Particles	222
A Vectorial Description of Scattering	223
Plots to Determine R_G and \bar{M}_w	224
The Guinier Plot	224
The Zimm Plot	225
The Determination of Molecular Shape	225
Scattering Using X-Rays and Neutrons	227
Contrast Variation in Neutron Scattering	228

The Effect of Scattering on Transmitted Light	230
Turbidity	231
Refractive Index	232
<i>The Frequency Dependence of the Refractive Index</i>	
Dispersion	233
<i>The Directional Properties of the Refractive Index:</i>	
Birefringence	234
Dynamic or Quasi-Elastic Light Scattering	234
Spectrum Analyzer or Optical Mixing Spectroscopy	235
Intensity Fluctuation or Correlation Spectroscopy	237
Problems	238

9 Raman Scattering

239

Overview	239
Raman and Resonance Scattering	240
Physical Picture	240
Selection Rule for Raman Scattering	242
Resonance Raman Scattering	243
Experimental Parameters	243
Position	243
Intensity	244
Polarization	244
Applications of Raman Spectroscopy	246
Conventional Raman Scattering	246
Resonance Raman Scattering	247
Pre-Resonance Raman Scattering	250
Problems	252

10 Optical Activity

255

Overview	255
Optical Activity	256

Optical Activity and Circularly Polarized Light	256
Parameters for Optical Activity	257
Measurement of ORD	259
Measurement of CD	259
The Frequency Dependence of ORD and CD	260
The Physical Basis of Optical Activity	261
Optically Active Chromophores	262
CD Spectra of Interacting Chromophores	264
The Use of CD to Determine Secondary Structure	265
Multicomponent Analysis	266
Empirical Uses of CD	269
Effects of Magnetic Fields on Optical Activity	270
Problems	273

11

Microscopy

279

Overview	279
Introduction	279
Factors That Affect Resolution	280
Resolving Power	281
Instrumentation	282
Lenses	282
Magnification	283
The Light Microscope	284
The Electron Microscope	284
The Preparation of Samples for Microscopy	286
Contrast in Microscopy	288
The Light Microscope	288
The Electron Microscope	290
Staining Procedures	290
The Light Microscope	290
The Electron Microscope	291

VII Fourier Transforms and Convolution Functions 359

VIII Magnetic Properties of Matter 361

IX Dipoles and the Interaction Between Them 362

The Interaction Between Dipoles 363

Two Parallel Dipoles 363

Two Dipoles in a General Conformation 363

X Spectra of Interacting Dimers 364

General References 369

Solutions to Problems 373

Index 391

Protein Crystallography	320
Methods Used to Depict 3-D Protein Structures	322
Classification of Proteins	324
Temperature Factors and Protein Mobility	325
The Validity of Protein Crystallography	326
Crystallography of Systems Other Than Proteins	326
Crystallography of Nucleotides and Polynucleotides	326
Problems	330

13 Other Spectroscopic Methods

333

Mössbauer Spectroscopy	333
Picosecond Spectroscopy	334
Photoacoustic Spectroscopy	336
Optical Detection of Magnetic Resonance	337
X-Ray Absorption Spectroscopy and Extended X-Ray Absorption Fine Structure (EXAFS)	338
Circular Polarization of the Luminescence (CPL)	340
Atomic Spectroscopy	341

Appendixes

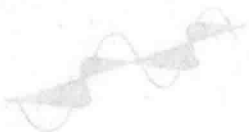
I	Mathematical Functions	343
	Complex Variables	343
	Exponential and Trigonometric Functions	343
	Vectors	344
II	Oscillators	345
	Simple Harmonic Oscillation	345
	Damped and Forced Oscillations	346
III	Waves and Their Superposition	349
IV	Wave Mechanics	351
V	Atomic and Molecular Orbitals	353
VI	Some Concepts of Crystal Field Theory	356

Advanced Techniques in Electron Microscopy	292
Underfocusing to Produce Phase Contrast	293
Optical Filtering Techniques	293
Image Reconstruction	294
Combination of Electron Diffraction with Microscopy	294
The Fluorescence Microscope	294
Problems	296

12 Diffraction

299

Overview	299
Introduction	300
Physical Principles of Diffraction Methods	300
Diffraction	300
Lattices	300
The Reciprocal Lattice	302
Fourier and Optical Transforms	302
Convolution	303
The Bragg Equation	305
Experimental Measurement of Diffraction	305
Sources of Radiation	305
The Sample in the Diffraction Experiment	306
Detection of the Diffraction Pattern	306
Interpretation	307
Direct Interpretation of Diffraction Data	307
<i>Determination of Molecular Weight</i>	307
<i>The Symmetry of the Molecule</i>	308
<i>Diffraction Patterns from Fibers</i>	309
Determination of Molecular Structure	311
<i>Fourier Synthesis, Fourier Transformation, and Patterson Functions</i>	311
<i>The Phase Problem and Its Solution</i>	314
<i>Determination of Molecular Structure from $\rho(x, y, z)$</i>	317
<i>Refinement</i>	318



Introduction

Most objects we see in everyday life are visible only because they reemit part of the light that falls on them from some source, such as the sun. Interpretation of this reflected or transmitted light can yield a wealth of information not only about the color and shape of an object but also about the atomic and molecular mechanisms involved when light interacts with the object.

Light is, in fact, a form of **electromagnetic radiation** and this book is concerned with the study of the interaction of electromagnetic waves with matter and how this can be used to extract information about biological molecules and cells.

Electromagnetic radiation covers an enormous range of wavelengths (energies, frequencies). The two extremes in this range are usually taken to be radio waves, with wavelengths around 10^{-1} m, and gamma rays, with wavelengths around 10^{-11} m. Visible light covers a very small range, $4-7 \times 10^{-7}$ m.

When light interacts with an object, we can normally see only reflected or transmitted radiation. Three phenomena that occur when electromagnetic radiation interacts with matter can be defined more precisely as **scattering**, (e.g., the sky is blue because fluctuating particles in the atmosphere scatter blue light more than red light); **absorption**, (e.g., red light absorbed by a piece of glass causes the transmitted light to appear blue); and **emission**, (e.g., a fluorescent dye may emit green light after absorbing blue light). Another result of the interaction of electromagnetic interaction with matter is **photochemistry**. This is obviously extremely important in biology (such as in vision and photosynthesis) but this aspect is not dealt with here.

We thus define **spectroscopy** as the study of the interaction of electromagnetic radiation with matter, excluding chemical effects. (For the purposes of this book, neutrons and electrons are considered to give rise to electromagnetic radiation, although this is not strictly correct; see Chapter 2.)

All the techniques described in this book involve (1) irradiation of a sample with some form of electromagnetic radiation; (2) measurement of the scattering, absorption, or emission in terms of some measured parameters (e.g., scattering intensity at some angle θ , extinction coefficient at a particular wavelength, or