**Garriott’s Medicolegal Aspects of Alcohol, Sixth Edition**

**Foreword**   
**Preface**

**Chapter 1. Chemistry of Alcoholic Beverages**   
Synopsis   
1.1 Introduction   
1.2 Description and History of Common Alcoholic Beverages   
A. Fermented Alcoholic Beverages   
B. Distilled Alcoholic Beverages   
C. The Effects of Aging (Maturation)   
1.3 Fermentation   
A. Yeasts   
B. Bacterial Contamination   
1.4 Nutritional Value of Alcoholic Beverages   
A. Carbohydrates   
B. Proteins   
C. Fats   
D. Vitamins and Minerals   
1.5 Antimicrobial Properties of Alcoholic Beverages   
1.6 Cancer and Alcohol   
1.7 Ethyl Alcohol Content   
1.8 Congeners   
1.9 Classification of Congeners   
A. Volatile Congeners   
B. Alcohols   
C. Aldehydes   
D. Esters   
E. Alcohols, Aldehydes, and Esters   
F. Common Acids   
G. Ketones   
H. Phenols   
1.10 Vasoactive Congeners   
A. Tyramine   
B. Histamines   
C. Ethanol and Grain Components   
D. Toxic Metals   
1.11 Congeners from Spices and Herbs   
1.12 Semivolatile Congeners   
References

**Chapter 2. Pharmacology and Toxicology of Alcohol**   
2.1 Introduction   
2.2 Skin   
2.3 Gastrointestinal Tract   
2.4 Cardiovascular System   
2.5 Liver   
2.6 Kidneys   
2.7 Endocrine System   
2.8 Teratogenicity   
2.9 Central Nervous System   
A. Chronic CNS Effects   
B. Blackout   
2.10 Impairment of Specific Functions Related to Driving Ability   
A. Vision   
B. Auditory discrimination   
C. Other sensory effects   
D. Reaction time   
E. Review of Research On Alcohol Impairment of Driving/Piloting Skills   
1. Motor vehicle   
2. Motorcycle   
3. Aviation   
2.11 Effects of Alcohol in Combination with Other Drugs   
A. Acetaminophen/Salicylate   
B. Amphetamines   
C. Antidepressants   
D. Barbiturates   
E. Benzodiazepines   
F. Caffeine   
G. Cocaine   
H. Histamine2-Receptor Antagonists   
I. Marijuana   
J. Opioids   
2.12 Antagonists to Alcohol and Pharmacotherapeutic Agents for Alcoholism   
A. Disulfiram (Antabuse) and Other Acetaldehyde Antagonists   
B. Narcotic Antagonists   
C. Acamprosate   
D. Other drugs   
2.13 Effects on Children and Adolescents   
2.14 Tolerance and Dependence   
References

**Chapter 3. Disposition and Fate of Ethanol in the Body**   
3.1 Introduction   
3.2 Fate of Drugs in the Body   
3.3 Forensic Science Aspects of Alcohol   
3.4 Ethyl Alcohol   
A. Chemistry   
B. Amounts of Alcohol Consumed   
C. Alcoholic Beverages   
D. Analysis of Ethanol in Body Fluids   
E. Reporting Blood Alcohol Concentration   
F. Water Content of Biofluids   
3.5 Alcohol in the Body   
A. Endogenous Ethanol   
B. Absorption   
C. Distribution   
D. Metabolism   
3.6 Pharmacokinetics of Ethanol   
A. First-Order Kinetics   
B. Zero-Order Kinetics   
C. Non-Linear Saturation Kinetics   
D. The Widmark Equation   
E. Updating the Widmark Equation   
F. Pharmacokinetics of Ethanol Metabolites   
G. Physiological Range of Ethanol Elimination Rates   
3.7 Characteristics of Blood-Alcohol Curves   
A. Ingestion of Alcohol on an Empty Stomach   
B. Inter- and Intra-Individual Variations   
C. Factors Influencing Cmax and tmax   
D. Effects of Food in the Stomach   
E. Gender Differences   
F. Repetitive Drinking   
G. Effect of Age on Widmark Parameters   
H. Blood-Alcohol Profiles after Drinking Beer   
I. Retrograde Extrapolation   
J. Massive Ingestion of Alcohol under Real-World Conditions   
K. Effects of Drugs on Metabolism of Ethanol   
L. Elimination Rates Ethanol in Alcoholics During Detoxification   
M. Ethanol Metabolism in Pathological States   
N. Short-Term Fluctuations in Blood-Alcohol Profiles   
O. Intravenous vs. Oral Route of Ethanol Administration   
3.8 Ethanol in Body Fluids and Tissues   
A. Water Content of Specimens   
B. Urine   
C. Breath   
D. Saliva   
E. Cerebrospinal Fluid (CSF)   
F. Tears   
G. Sweat   
H. Mother's Milk   
I. Brain and Body Organs   
J. Vitreous Humor   
K. Hair   
3.9 Concluding Remarks   
References

**Chapter 4. Biomarkers of Acute and Chronic Alcohol Ingestion**   
4.1 Introduction   
4.2 Alcohol Toxicity   
A. Physical and Sociological Consequences of Alcohol Abuse   
B. Alcohol-Related Impairment   
C. Blood Alcohol Concentration   
D. Alcohol Hangover   
E. Alcohol-Related Liver Disease   
4.3 Quantity of Alcohol Consumed   
A. Definition of a Standard Drink   
4.4 Alcohol in the Body   
A. Absorption from the Gut   
B. Distribution in All Body Fluids and Tissues   
C. Elimination via Excretion and Metabolism   
D. Oxidative Metabolism of Ethanol   
E. Metabolic Consequences   
4.5 Evaluating Drinking Habits   
A. Questionnaires and Self-Reports   
B. Biochemical Markers of Alcohol Problems   
C. Markers of Acute Alcohol Ingestion   
D. Methanol as a marker of ethanol use   
E. Urinary Metabolites of Serotonin   
F. Non-Oxidative Metabolites of Ethanol   
4.6 Long Term Markers of Ethanol Abuse   
A. Carbohydrate Deficient Transferrin (CDT)   
B. Gamma-glutamyltransferase (GGT)   
C. Mean Corpuscular Volume (MCV)   
D. Other Biomarkers of Excessive Drinking   
4.7 Forensic Applications of Biomarkers   
A. Postmortem Toxicology   
B. Control of Abstinence   
C. Alcohol Biomarkers in Hair   
D. Traffic Medicine   
4.8 Efficacy of Diagnostic Screening Tests   
A. Sensitivity and Specificity   
B. Positive and Negative Predictive Values   
4.9 Conclusion   
References

**Chapter 5. Specimen Considerations for Alcohol Testing**   
5.1 Introduction   
5.2 Blood   
A. General Considerations   
B. Antemortem Sources of Blood Specimens   
C. Postmortem Sources of Blood Specimens   
5.3 Serum and Plasma   
5.4 Urine   
5.5 Saliva (Oral Fluid)   
5.6 Brain and Cerebrospinal Fluid   
5.7 Vitreous Humor   
5.8 Bile   
5.9 Skeletal Muscle   
5.10 Intracerebral Blood Clots   
5.11 Gastric Contents   
5.12 Other Specimens   
5.13 Considerations for Interpretation Postmortem Specimens   
A. Interfering Volatile Substances   
B. Effects of Embalming   
C. Diffusion of Alcohol   
D. Postmortem Decomposition   
E. Antemortem Dilution   
References

**Chapter 6. Physiological Basis and Practice of Breath Alcohol Determination**   
6.1 Introduction   
6.2 Chemistry of Ethyl Alcohol   
6.3 Impairment by Ethyl Alcohol   
6.4 Alcohol in the Body   
A. Pharmacokinetics   
B. Absorption   
C. Distribution   
D. Elimination   
E. Circulatory System   
F. Pulmonary System   
6.5 Blood Breath Relationships   
A. General   
B. Henry's Law   
C. Fick's Law   
6.6 Why Breath Tests of Blood-Alcohol Don't Work   
6.7 Why Breath Tests of Blood-Alcohol Do Work   
6.8 Breath Temperature   
6.9 Elements of a Forensic Breath Test Program   
6.10 Alcohol Test Programs   
6.11 Recommendations of the National Safety Council - Committee on Alcohol and Other Drugs (now the NSC Alcohol and Drug Impairment Division)   
6.12 Conclusion   
References

**Chapter 7. Methods for Breath Alcohol Testing**   
7.1 Introduction   
7.2 Sampling Breath for Alcohol Analysis   
A. End-expiratory Breath is the Desired Specimen   
B. Residual Mouth Alcohol   
C. Condensation Losses, Carryover   
D. Additional Steps   
7.3 Breath Alcohol Testing Instrumentation   
A. Testing Instruments   
1. Passive alcohol sensor (PAS)   
2. Screening device   
3. Ignition interlock device   
4. Evidential breath tester   
B. Calibrating Units   
7.4 Requirements for Evidential Breath Testing   
A. General   
B. Data Collection   
C. Maintaining Reliability   
D. Federal Specifications   
7.5 Challenges to the Validity of Breath Alcohol Results   
A. Rules, Regulations and Documentation   
B. Specificity   
C. Residual Mouth Alcohol   
D. Blood:Breath Alcohol Ratio   
E. Radio Frequency Interference   
F. Instrument Variability   
7.6 Breath Alcohol Testing Instruments   
A. Infrared Spectroscopy   
1. Intoxilyzerr 8000   
2. Intoxilyzerr 9000   
3. Intox DMT   
B. Electrochemical Oxidation/Fuel Cell   
1. Intox EC/IR II   
2. RBT IV   
3. Alco-Sensor FSTr   
4. Alco-Sensorr VXL   
5. Intoxilyzerr S-D5   
6. Alcotestr 6510, Alcotestr 6810   
7. Alcotestr 7510, Alcotestr 8610   
8. Lifeloc FC20, FC20BT   
C. Dual Detector: Infrared/Fuel Cell   
1. Alcotest 9510   
Trademarks   
Endnotes   
References

**Chapter 8. Methods for Biological Specimen Alcohol Testing**   
8.1 Introduction   
8.2 Chemical Methods (Colorimetric)   
8.3 Biochemical Methods (Enzymatic)   
8.4 Gas Chromatographic Methods   
A. Extraction Techniques   
B. Distillation Techniques   
C. Direct Injection Techniques   
D. Headspace Sampling   
8.5 Gas Chromatography-Mass Spectrometry   
8.6 Analysis of Volatiles- General Considerations   
A. Specimen preparation   
B. Calibrators and controls   
C. Analysis   
D. Assay validation   
E. Proficiency testing   
References   
Endnotes

**Chapter 9. Quality Assurance for Biological Specimen Alcohol Measurements**   
9.1 Introduction   
9.2 Pre-testing Issues 27   
A. Collection Tubes and Directions   
9.3 The Laboratory   
A. Personnel   
9.4 Testing   
A. Specimen Suitability for Testing   
B. Analytical Methods-Calibration   
C. Validation and Approaches to Calibration   
D. Quality Control and Matrix Validation   
E. Batch Analysis   
F. Quality Control   
G. Acceptance Criteria   
H. Monitoring Quality Control Performance   
I. Instrument Maintenance   
J. Proficiency Tests   
9.5 Post Testing   
A. Reporting   
B. Uncertainty   
C. Records and Specimen Retention   
References and Bibliography   
Reference Materials and Controls   
Proficiency Testing Programs

**Chapter 10. Collection and Storage of Specimens for Alcohol Testing**   
10.1 Introduction   
10.2 Loss of Ethanol   
A. Evaporation   
B. Oxidation   
C. Microbial Action   
D. Recommendations to Prevent Ethanol Loss   
10.3 Ethanol Gain   
A. Physical Contamination   
B. Production of Ethanol by Microorganisms   
C. Recognition of Postmortem Generation of Alcohol   
10.4 Preservation of Biological Specimens   
A. Collection of Specimens from Living Subjects   
B. Collection of Postmortem Specimens   
10.5 Conclusions   
References

**Chapter 11. Alcohol Effects and Driving Impairment**   
11.1 Introduction   
11.2 The Presence of Alcohol in Drivers   
11.3 Alcohol and Accidents   
11.4 Single-Vehicle Collisions   
11.5 Measures of Intoxication   
11.6 Driving Abilities Impaired by Alcohol   
11.7 Rate of Alcohol Consumption   
11.8 Alcohol and Fatigue   
11.9 Alcohol and Memory   
11.10 Alcohol and Aggression   
11.11 Alcohol and Degree of Injury   
Endnote   
References

**Chapter 12. Standardized Field Sobriety Testing**   
12.1 Role of Standardized Field Sobriety Testing in Impaired Driving Enforcement   
12.2 Role of the National Highway Traffic Safety Administration (NHTSA)   
12.3 Standardized Field Sobriety Testing   
A. Components of SFST   
References

**Chapter 13. Epidemiologic Basis of Alcohol-Induced Psychomotor Performance Impairment**   
13.1 Introduction   
13.2 Establishing the Relationship   
13.3 Working Through The Ambiguities   
13.4 Chronological Development of Epidemiology Database   
13.5 North American Studies   
13.6 International Studies   
13.7 Have Our Actions From Studying Epidemiological Studies Produced Effects?   
13.8 Summary   
13.9 Dedication   
13.10 Acknowledgements   
References

**Chapter 14. Experimental Basis of Alcohol-Induced Psychomotor Performance Impairment**   
14.1 Introduction   
14.2 Observation and Measurement of Alcohol Performance Impairment   
14.3 Psychomotor Performance Testing   
A. Driving Simulators   
B. Roadside Testing or Field Sobriety Testing (FST)   
C. Impairment When BACs Are Between 0.00-0.079 g/dL   
D. Impairment at BAC = 0.10 g/dL   
E. Alcohol and Drug Interactions   
14.4 Application of Performance Information to DUI-DWI   
14.5 Conclusions   
14.6 Dedication   
14.7 Acknowledgement   
References

**Chapter 15. Physical Manifestation of Alcohol Intoxication**   
15.1 Introduction   
15.2 Legal Statutes   
15.3 Case Presentation   
15.4 Blood Alcohol Concentration and Lack Of Visible or Obvious Intoxication   
15.5 Conclusion   
References

**Chapter 16. Clinical Aspects of Alcohol Testing**   
16.1 Introduction   
16.2 Pre-analytical variables   
16.3 Clinical Considerations   
A. The Patient   
B. Laboratory-based Patient Assessment   
C. Hypoglycemia   
D. Alcoholic Ketoacidosis (AKA)   
E. Thiamine Deficiency   
F. Anion Gap   
G. Osmol Gap   
16.4 Measurement of Alcohol   
16.5 Conclusions   
References

**Chapter 17. Alcohol Testing in the Workplace**   
17.1 Introduction   
A. Industries and Workplaces Affected by Alcohol   
B. Regulated and Non-Regulated Testing for Alcohol   
17.2 Some Legal Aspects of Alcohol Testing in the Workplace   
A. In General   
B. The Regulatory Environment   
17.3 Features of Alcohol Testing in the Workplace   
A. Special Features of Workplace Testing for Alcohol   
B. Purpose of Alcohol Testing in the Workplace   
C. Alcohol Testing Categories and Indications for Alcohol Testing   
D. Reasonable Suspicion Testing   
E. Testing Locations: On-Site versus Off-Site   
17.4 Alcohol Testing Regulated by U.S. Department of Transportation   
A. Prohibited Conduct   
B. Required Alcohol Testing   
C. Features of Alcohol Testing Under DOT Regulations   
D. Significance, Interpretation and Consequences of Test Results   
E. Quality Assurance Aspects   
F. Statutory and Regulatory Changes in Transportation Workplace Alcohol Testing   
17.5 Testing Technology and Practices   
A. Analysis and Specimens   
B. Testing in the DOT Program   
C. Screening Tests   
D. Evidentiary Tests   
E. Calibrating Devices   
F. Training Requirements   
G. Testing in the Nuclear Regulatory Commission Programs   
17.6 Interpretation of Alcohol Test Results   
A. Acute Effects of Alcohol   
B. Combined Effects of Alcohol and Other Drugs   
C. Hangover Effects of Alcohol   
D. Abstention Period   
17.7 Acknowledgment   
References   
Endnotes

**Chapter 18. Statistical Applications in Forensic Toxicology**   
18.1 Basic Introductory Statistics   
18.2 Samples, Populations and Distributions   
A. Descriptive Statistics   
B. Inferential Statistics   
C. Regression Analysis   
D. Non-Parametric Statistical Analyses   
18.3 Transformations   
18.4 Bayesian Statistics   
18.5 Sample Size   
18.6 Duplicate Test Agreement Criteria   
A. Proficiency Testing   
18.7 Widmark's Equation   
18.8 Blood/Breath Alcohol Ratios   
18.9 Experimental Design   
18.10 Communicating Statistical/Numerical Information   
18.11 Conclusions   
Glossary of Terms   
Endnotes   
Practice Problems   
Appendix

**Chapter 19. Uncertainty in Blood and Breath Alcohol Measurements**   
19.1 Introduction   
19.2 Defining Measurement Uncertainty   
19.3 Basic Principles of Measurement   
A. Properties of Measurement   
B. Factors Contributing to Measurement Uncertainty   
C. General Approaches to Measurement Uncertainty   
D. General Steps for Estimating Measurement Uncertainty   
Example 1: Breath Alcohol Measurement Uncertainty   
Example 2: Blood Alcohol Measurement Uncertainty   
E. Treatment of Bias   
F. Other Approaches to Estimating Measurement Uncertainty   
1. Total Allowable Error   
2. Proficiency Testing   
3. Guard Band Approach   
4. Monte Carlo Approach   
19.4 Conclusions   
Endnotes

**Chapter 20. Application of ISO Standards to the Measurement of Alcohol**   
20.1 The State of Forensic Science   
A. The National Academy of Sciences Report   
B. Forensic Toxicology   
20.2 Credentialing the Organization and the Practitioner   
A. Accreditation   
B. Certification   
20.3 Standardization: A Basis for Accreditation   
A. International Organization for Standardization   
B. Standardization Economies   
C. ISO Standards   
D. Early Laboratory Standard Development   
E. Forensic Toxicology Laboratories and International Standards   
F. Amplification of the ISO Standard   
20.4 Accrediting the Accreditors   
A. Standards for the Certifying and Accrediting Boards   
B. International Recognition of Accrediting Bodies   
20.5 Quality Management   
A. The Beginnings of Quality   
B. Quality Assurance   
20.6 The Path to Accrediting a Laboratory   
A. Planning Ahead   
B. The Quality Manual   
C. The Quality Management System   
20.7 The National Commission on Forensic Science

**Chapter 21. Prosecution of the Alcohol-Impaired Driving Case**   
21.1 Introduction   
21.2 The Big Picture   
21.3 Complexity of Prosecuting the Impaired Driving Case   
21.4 The Alcohol-Impaired Driving Case   
21.5 Factual Witnesses   
21.6 Expert Witnesses   
21.7 Preparing for Court Prior to Being Called to Trial   
References   
Endnotes

**Chapter 22. Defense of Driving Under the Influence Cases**   
22.1 Introduction   
22.2 Driving and Field Sobriety Testing   
A. Overview: National Highway Traffic Safety Administration   
B. Driving Behavior   
C. Standardized Field Sobriety Testing (SFST) Validation Studies   
D. Legal Analysis and Summary of the SFST Validation Studies   
E. Final Thoughts on the Standardized Field Sobriety Test Battery   
22.3 Drug Recognition Evaluation   
A. Overview   
B. DRE Statutory Law   
C. DRE Case law   
D. The 12-Step Protocol   
E. Deconstruction and Analysis of the 12-Step Protocol   
F. Effects of Various Drugs   
G. Drug Evaluation and Classification Protocol (DECP)   
22.4 Chemical Testing   
A. Preliminary Breath Testing/Preliminary Alcohol Screening   
B. Safeguards   
C. Commonly Used PBT Devices   
D. Evidential Breath Testing   
E. Breath Testing: Methods of Attack   
F. Calibration   
G. Blood Testing: Methods of Attack from the Vein to the Lab   
H. Headspace Gas Chromatography   
I. Secondary Blood Testing   
22.5 BAC Calculations for Attorneys   
A. Determining the One-Drink Potential   
B. Elimination and Retrograde Extrapolation   
C. White's Retrograde Extrapolation   
D. Partition Ratio Conversions   
E. Unit Conversions   
References

**Chapter 23. Legal Proceedings and the Expert Witness**   
23.1 Introduction   
23.2 The Need for Expert Witnesses   
23.3 What is an Expert Witness?   
23.4 Financial Issues   
23.5 The Law of Evidence   
A. Overview   
B. Burden of Proof   
23.6 Degree of Evidence Required to Sustain the Burden of Proof   
A. Beyond a Reasonable Doubt   
B. Preponderance of the Evidence   
C. Clear and Convincing Evidence   
23.7 Reconciling Statistical Confidence Levels and Legal Proof   
23.8 Categories of Evidence   
23.9 Expert Reports   
23.10 Diagrams and Demonstrative Evidence   
23.11 The Threshold Question of Admissibility   
23.12 Discovery and the Expert Witness   
A. The Discovery Process   
B. If You Are Contacted by the Opposing Attorney   
C. Informal Interviews   
D. Written Interrogatories   
E. Affidavits   
F. The Subpoena   
G. If You Are Subpoenaed   
H. The Deposition   
I. Depositions Are Used For:   
23.13 Elements of Testimony   
A. Voir Dire   
B. Direct Examination or Examination in Chief   
C. Cross-Examination   
D. Re-Direct   
E. Credibility and Communication   
F. Credibility Determinations and the Jury   
G. Credentials and Your Testimony   
23.14 Keys to Effective Testimony   
A. Before You Get to the Witness Stand   
B. In the Courtroom   
C. On the Stand   
D. The "Don'ts"   
E. Final Pointers   
23.15 The Nature of Litigation   
A. Hurry Up and Wait   
B. Variables in Litigation   
Selected Reading

**Chapter 24. Alcohol and Civil Litigation**   
24.1 Introduction   
24.2 Alcohol Injury Epidemiology   
24.3 Alcohol Intoxication Effects in Litigation 65   
24.4 Differences between Civil litigation involving alcohol from criminal litigation/DUI   
24.5 Settings for Alcohol Related Litigation   
A. Employment   
24.6 Police Activities   
A. Pursuit   
B. Excessive Force   
24.7 Motor Vehicle Collisions   
A. Vehicle/Vehicle   
B. Motorcycle cases   
C. Boating   
24.8 Alcohol and Fall Risk   
A. Stairs - no alcohol test - fall on Bar Stairs   
B. Stairs - residential stairs fall   
24.9 Family Law - Biomarkers for Alcohol   
24.10 Conclusion   
References