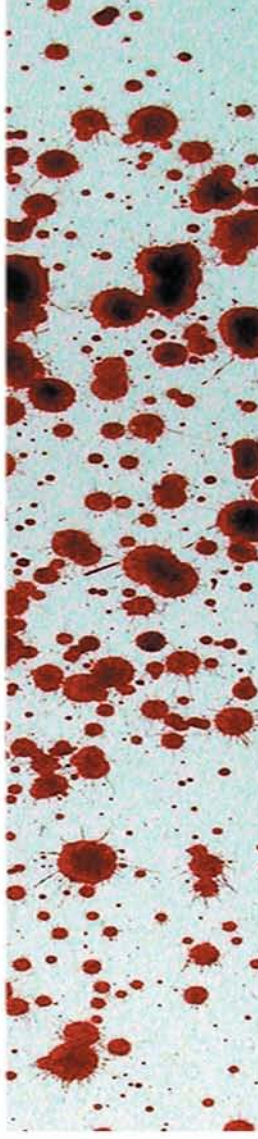
Principles of Bloodstain Pattern Analysis

Theory and Practice



Stuart H. James
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Principles of Bloodstain Pattern Analysis

Theory and Practice

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Foreword

The discipline of Bloodstain Pattern Analysis has advanced to the level that if "blood evidence"exists investigators and prosecutors want and should have an interpretation. To do less would be nothing short of ignoring valuable physical evidence.

The evolution of this evidence has been driven by discovery and fueled by DNA. By using methodical, scientific principles, crime scene information can be discovered. This information will re-create events that support or refute witness statements and will assist the court in determining intent and help the jury to visualize the final moments. The language of bloodstain pattern analysis will provide information that cannot be gained by other means. Let the physical evidence speak for itself and tell the stories of self-defense or intent to commit murder.

As a bloodstain pattern analyst I relish in the opportunity to gain further insight into this discipline, sometimes as confirmation that a different approach can gain the same result or that this new approach provides a more in-depth review of my case. In any event I seek to articulate this evidence so that those concerned will gain the same confidence that I have.

The logic of bloodstain pattern analysis can sometimes be a trap. Just when you think that you know how to interpret patterns, they give you a different twist. Given classic patterns it is not difficult to determine their origin; however, we know that crime scenes are not predictable. The evidence is more often a combination or a portion of the patterns we know. This subject requires a complete understanding of all aspects of the case. The ability to apply training, knowledge, and common sense is key to a successful interpretation of a bloodletting scene. If you want to fully understand the intricacies of bloodstains you need only refer to the table of contents in this book. Where, when, and how do we begin? Is blood a unique substance? How do we recognize one pattern or event from another? Is it possible to alter a bloodstain pattern? What equipment will we need? How do we get this evidence to court? What if the bloodstains have been entirely or partially cleaned up? Is there an error rate, and how do we explain our results to a jury?

I believe that this book will meet your requirements and I would recommend it to readers at every level. Those who are researching at a college or university level will benefit as much as those who are working in the field of forensic science, or otherwise involved in the criminal justice system. The completeness of this book is a testament to the authors. Those involved in the field of bloodstain pattern analysis, even to the slightest degree, will recognize their names.

The authors are forensic scientists who have gained the respect of the bloodstain analysis community through years of work, not only through painstaking analysis of bloodletting evidence but also through expert courtroom testimony. As you look at these names you will also see teachers—people who take the time and care to share their knowledge. Years of

expertise have come together to write one of the most comprehensive texts on the subject. The reader need only turn these pages with a mild interest to become both fascinated and educated.

Pat Laturnus
Bloodstain Pattern Analyst
Instructor–Ontario Police College
Ontario, Canada
Retired–Royal Canadian Mounted Police

Preface

Principles of Bloodstain Pattern Analysis: Theory and Practice presents an in-depth text of bloodstain pattern analysis that emphasizes a modern thought process of a taxonomic classification of bloodstains based on their physical characteristics of size, shape, and distribution as well as the specific mechanisms that produce them. The concept of a multidisciplinary approach using scene and laboratory examinations in conjunction with forensic pathology, forensic serology, and chemical enhancement techniques is also presented to the reader. The technical content and quality of this book is increased dramatically with color images of bloodletting injuries, bloodstains, and crime scenes. Case studies are presented within individual chapters, and the book is complimented by two chapters that discuss details of legal issues as they pertain to bloodstain pattern analysis. The coauthors, Stuart H. James, Paul Erwin Kish, and T. Paulette Sutton, form a nucleus of bloodstain pattern analysts, each with many years of experience in casework and teaching of basic and advanced bloodstain pattern analysis courses.

The chapters that present the scientific principles and practical application of bloodstain pattern analysis represent the combined efforts of the authors. They have invited other respected and qualified forensic scientists and attorneys to contribute chapters in their specialties, which has enhanced the quality and scope of the text. The chapters are arranged in a logical order with Chapter 1, "Introduction to Bloodstain Pattern Analysis," discussing the evolution of bloodstain pattern analysis from significant historical events to its current level as a discipline within the forensic sciences.

Chapter 2, "Medical and Anatomic Aspects of Bloodshed," contributed by forensic pathologist Dr. Ronald K. Wright, MD, JD, provides an overview of the circulation of blood within the body and the rate of bleeding and blood volume loss resulting from medical conditions and specific injuries. He has also included an interesting section that describes postmortem lividity and identifiable patterned abrasions and bruises on the skin. The authors agreed that this chapter was essential to the bloodstain pattern analyst for the understanding of mechanisms of bleeding within and outside the body of the victim.

Chapter 3, "Biological and Physical Properties of Human Blood," explains the cellular components of human blood and their functions within the body supplemented with excellent color images. The physical properties of blood relative to its behavior as a liquid outside the body is essential for the bloodstain analyst to appreciate in terms of bloodstain formation. The principles of physics pertaining to surface tension, adhesion and cohesion, relative density, viscosity, and the non-Newtonian behavior of blood are defined.

Chapter 4, "Physical Properties of Bloodstain Formation," applies the physical properties of blood to the shape of an airborne drop or droplet of blood and the size and shape of resultant bloodstains on horizontal and nonhorizontal surfaces. This chapter also describes the taxonomic classification of bloodstains that will be the emphasis in subsequent chapters of bloodstain pattern analysis.

Chapter 5, "Passive Bloodstains," is a detailed chapter that describes a major category of bloodstains. This chapter is supplemented with numerous color images that afford the reader many examples of this important taxonomic classification of bloodstains.

Chapter 6, "Formation of Spatter and Spatter Associated with a Secondary Mechanism," discusses the physical characteristics of spatter formation relative to stain size, shape, quantity, location, and distribution relative to its taxonomic classification. Emphasis is given to mechanisms associated with the creation of spatter patterns and the important ability of the bloodstain analyst to recognize the overlapping of stain sizes created by different mechanisms and the caution to be exercised in making a determination.

Chapter 7, "Impact Spatter Mechanisms," describes the production of spatter produced as the result of beating, stabbing, gunshot, explosion, and power tool events. Factors that limit the production of impact spatter are emphasized.

Chapter 8, "Spatter Associated with a Projection Mechanism," presents the characteristics of bloodstains and patterns produced by arterial, expiratory, and cast-off mechanisms. The uniqueness of the patterns as well as the overlap of stain size within a pattern that can be confused with impact spatter mechanisms is demonstrated.

Chapter 9, "Altered Bloodstain Patterns," is a chapter that applies to all categories of bloodstains because physical or biological alterations such as drying, clotting, dilution, insect activity, and effects of fire are frequently encountered in casework. Recognition of these alterations cannot be overemphasized. Void patterns and sequencing of bloodstain patterns are also included in this chapter.

Chapter 10, "Determination of the Area of Convergence and Area of Origin of Bloodstain Patterns," is a chapter devoted to the reconstruction of bloodstain events using the principles of mathematics, including trigonometry. Various methods of the determination of areas of convergence and origin are explained.

Chapter 11, "Directional Analysis of Bloodstain Patterns with a Computer," contributed by Dr. Alfred L. Carter with case studies provided by Craig C. Moore and Mike Illes, describes the BackTrack program devised by Dr. Carter for the measurement of bloodstains and the determination of areas of convergence and origin.

Chapter 12, "Documentation and Examination of Bloodstain Evidence," details the methods of preparing sketches, diagrams, photographs, and videos of bloodstain evidence at the scene as well as at the laboratory, where the examination of bloodstained clothing is crucial prior to testing for DNA analysis.

Chapter 13, "Examination of Bloodstain Patterns at the Scene," describes additional detail for proper processing of crime scenes and sample collection, including vehicles for bloodstain pattern analysis. An important feature of this chapter is the examination of the body of the victim for bloodstain patterns.

Chapter 14, "Presumptive Testing and Species Determination of Blood and Bloodstains," contributed by Robert Spalding, describes the various presumptive tests for blood, including their applications and limitations. Mr. Spalding also explains the confirmatory tests for blood and determination of species of origin.

Chapter 15, "The Detection of Blood Using Luminol," contributed by Dale Laux, explains the luminol reaction, its preparation, its use, and interpretation of patterns revealed by this chemi-luminescent reagent. The principles of luminol photography with excellent images are provided as well as the effect of the use of luminol on the subsequent analysis of bloodstains.

Chapter 16, "Chemical Enhancement of Latent Bloodstain Impressions," contributed by Martin Eversdijk, is an important addition to this text. Martin methodically describes selected methods for the chemical dye enhancement of trace impressions of blood augmented with excellent images of bloody enhanced fingerprints, palm prints, and footwear.

Chapter 17, "Approaching the Bloodstain Pattern Case," explains the importance of the examination of all relevant information and the logical sequential approach to case evaluation for the bloodstain analyst. The chapter emphasizes the utilization information from all involved forensic disciplines for the proper synthesizing of the available data and the scientific formulation and testing of hypotheses.

Chapter 18, "Report Writing," is an expansion of an excellent chapter by Paul E. Kish that appeared in the text, *Scientific and Legal Applications of Bloodstain Pattern Interpretation*. It is a logical format for the writing of a bloodstain pattern analysis report from introduction to final conclusions.

Chapter 19, "Legal and Ethical Aspects of Bloodstain Pattern Evidence," contributed by Carol Henderson and Brittan Mitchell, is updated from the text, *Scientific and Legal Applications of Bloodstain Pattern Interpretation*. This chapter details the issues of the admissibility, weight of the bloodstain evidence, and the qualifications of the bloodstain analyst who is called on to provide expert testimony in court. Methods of direct and cross-examination are discussed as well as ethical issues of the attorney and the expert.

Chapter 20, "Bloodstain Pattern Analysis: Postconviction and Appellate Application," contributed by Marie Saccoccio also has been updated from the text, *Scientific and Legal Applications of Bloodstain Pattern Interpretation*. She discusses the role of the postconviction attorney and the appeal process with case examples.

Finally, the Appendices supplement the text with scientific data including trigonometric tables, metric equivalents, and scene and laboratory checklists and biohazard safety precautions. Additionally, court decisions relating to bloodstain pattern analysis and presumptive blood testing are included. Numerous references are provided for bloodstain pattern analysis and the related topics.

The goal of the authors and contributors was to provide an up-to-date bloodstain pattern analysis text for crime scene investigators, forensic laboratory personnel, forensic pathologists, and prosecutors and defense attorneys within the criminal justice system. As Professor Andre A. Moenssens stated in an article entitled "Novel Scientific Evidence in Criminal Cases," published in the *Journal of Criminal Law and Criminology* in 1993:

> Attorneys have the responsibility to learn about the scientific evidence that they wish to admit. If the attorneys who are questioning and cross-examining the expert witnesses have a working knowledge of bloodstain pattern analysis, they will be better equipped to distinguish between those experts with sufficient qualifications and those without them. Also, attorneys will be able to more capably critique an expert's testimony and limit or eliminate conclusions that are speculative or over-stated. Unless attorneys know what questions to ask during cross-examination, much of what the witness testifies to will go unchallenged.

Stuart H. James

Paul E. Kish

T. Paulette Sutton

The Authors

Stuart H. James of James and Associates Forensic Consultants, Inc. is a graduate of Hobart College where he received a BA degree in biology and chemistry in 1962. He received his MT(ASCP) in medical technology from St. Mary's Hospital in Tucson, Arizona in 1963. Graduate courses completed at Elmira College included homicide investigation, bloodstain pattern analysis, and forensic microscopy. He has completed more than 300 hours of continuing education and training in death investigation and bloodstain pattern analysis. A former crime laboratory supervisor in Binghamton, New York, he has been a private consultant since 1981.

Mr. James has instructed in Forensic Science at the State University of New York and Broome Community College in Binghamton, New York. Additionally, he has lectured on the subjects of bloodstain pattern analysis and forensic science throughout the United States and abroad. He has instructed basic and advanced bloodstain pattern analysis courses with Paul E. Kish in Pontiac, Michigan, Appleton Wisconsin, Suffolk University in Boston, Massachusetts, the Henry C. Lee Institute at the University of New Haven in West Haven, Connecticut, the Centre of Forensic Sciences in Toronto, Canada, the Politie LSOP Institute for Criminal Investigation and Crime Science in Zutphen, The Netherlands and the University of Newcastle upon Tyne in the United Kingdom.

He has been consulted on homicide cases in 46 States and the District of Columbia as well as in Australia, Canada, Germany, South Korea, and the US Virgin Islands and has provided expert testimony in many of these jurisdictions in state, federal, and military courts.

Mr. James was a co-author of the text entitled, *Interpretation of Bloodstain Evidence at Crime Scenes.* He was also the Editor of *Scientific and Legal Applications of Bloodstain Pattern Interpretation* both of which were published in 1998. He is a co-editor with Jon J. Nordby of the text entitled *Forensic Science*: *An Introduction to Scientific and Investigative Techniques* published in 2003. Mr. James is a fellow in the American Academy of Forensic Sciences and a distinguished member of the International Association of Bloodstain Pattern Analysts (IABPA) as well as the current editor of the quarterly IABPA News. He is also a member of the Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN).

Paul Erwin Kish is a consulting bloodstain pattern analyst in Corning, New York, as well as, an adjunct Instructor in the Criminal Justice Program at Elmira College. He holds a B.S. degree in Criminal Justice and an M.S. degree in Education from Elmira College. He has been consulted on homicide cases in 30 states within the United States and 7 countries while presenting expert testimony in 16 states, the District of Columbia, and Canada.

Mr. Kish is an internationally known lecturer on the subject of bloodstain pattern analysis. He has taught Basic Bloodstain Pattern Analysis courses throughout the United States, as well as, in Canada, The Netherlands, United Kingdom, and Sweden. He has educated over 850 students from 17 countries during these weeklong basic bloodstain pattern analysis courses. He has taught Advanced Bloodstain Pattern Analysis courses in the United States, The

Netherlands, and United Kingdom. He has lectured extensively throughout the United States at forensic and law related conferences and seminars.

He has authored various articles on the topic of bloodstain pattern analysis including contributions to the texts *Scientific and Legal Applications of Bloodstain Pattern Interpretation* (CRC Press, 1998); *Forensic Science: An Introduction to Scientific and Investigative Techniques* (CRC Press, 2003). Mr. Kish is an associate editor of the International Association of Bloodstain Pattern Analysts News having served as Editor for two years. He is a fellow in the American Academy of Forensic Sciences, a member of the Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN), the International Association of Bloodstain Pattern Analysts, Canadian Society of Forensic Science, and International Association for Identification.

T. Paulette Sutton is an Associate Professor of Clinical Laboratory Sciences and Assistant Director of Forensic Services at the University of Tennessee Health Science Center in Memphis. She holds a B.S. in Medical Technology from the University of Tennessee and a M.S. in Operations Management Engineering from the University of Arkansas. She has practiced as a forensic serologist and bloodstain pattern analyst at the University of Tennessee, Memphis for the past 28 years and is also a member of the crime scene team for the Shelby County Medical Examiner's Office (Memphis). Sutton has been consulted on cases in many states and federal jurisdictions and has given expert testimony in criminal, as well as civil cases, in for both prosecution and defense. She has taught basic and advanced Bloodstain Analysis courses, as well as developing and teaching a course devoted entirely to the documentation of bloodstain pattern evidence. Ms. Sutton has lectured extensively on bloodstain pattern analysis and has received the Lecturer of Merit and the Distinguished Faculty awards from the National College of District Attorneys.

Ms. Sutton has contributed to the texts *Interpretation of Bloodstain Evidence at Crime Scenes*, 2nd edition (CRC Press, 1998); *Scientific and Legal Applications of Bloodstain Pattern Interpretation* (CRC Press, 1998); *Forensic Science: An Introduction to Scientific and Investigative Techniques* (CRC Press, 2003) and authored didactic and laboratory exercise manuals *Bloodstain Pattern Analysis in Violent Crimes*. She has authored numerous articles on forensic serology and on bloodstain pattern analysis and serves as an associate editor of the International Association of Bloodstain Pattern Analysts News. Sutton is a member of the International Association for Identification, the International Association of Bloodstain Pattern Analysts and the Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN).

Contributors

Alfred L. Carter is a retired Professor of Physics at Carleton University in Ottawa, Canada. He has done extensive work in the computer analysis of bloodstains and developed software for this application. He is a member of the International Association of Bloodstain Pattern Analysts. He has consulted with the Royal Canadian Mounted Police in Ottawa, Canada and has taught computer analysis of bloodstains in both Canada and the United States.

Martin Eversdijk began his career with the Dutch Police in 1986 and joined the Forensic Scene of Crime Department in the city of Amstelveen in 1993. He became a staff member/trainer at the Institute for Criminal Investigation and Crime Science, a national training center for forensic scene of crime officers in the Netherlands. He conducts research and teaches in the areas of bloodstain pattern analysis, blood searching techniques and blood enhancement techniques. Mr. Eversdijk is a member of the International Association of Bloodstain Pattern Analysts and the FBI Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN).

Carol Henderson is Director of the National Clearing House for Science, Technology and the Law and a Visiting Professor of Law at Stetson University College of Law in Gulfport, Florida. She is Vice President of the American Academy of Forensic Sciences and has served on the Board of Directors and as Chairman of the Jurisprudence Section. She is co-editor of the *Encyclopedia of Forensic and Legal Medicine* published by Elsevier and a co-author of the 4th Edition of *Scientific Evidence in Civil and Criminal Cases* with Moenssens, Starrs and Inbau published by The Foundation Press in 1995. She is the author of more than 40 articles on scientific evidence and ethics.

Mike Illes has been a member of the Ontario Provincial Police for the past 18 years. He has been involved in the field of forensics for 14 years and is the Unit Commander of the Central Region Forensic Identification Unit located in Peterborough, Ontario. In 1994 Sergeant Illes received training in Basic Bloodstain Pattern Recognition in the United States. He completed the RCMP Forensic Bloodstain Pattern Analyst program and RCMP Math and Physics Course in 1995. Sergeant Illes is internationally known for his work in Bloodstain Pattern Analysis. He has done bloodstain crime scene work in Canada (Ontario and Newfoundland), the United States and Holland. He has given expert opinion evidence in the Canadian and Netherlands Court systems. Sergeant Illes has conducted forensic lectures and training courses in Canada, the United States and the Netherlands. Sergeant Illes sits on the Trent University/Sir Sandford Fleming College Forensic Degree Program Advisory Committee and is an instructor for that program. He is also a member of the FBI Scientific Working Group for Bloodstain Pattern Analysis (SWGSTAIN).

Dale Laux began his forensic career in 1980 after graduating from The Ohio State University with a Masters of Science degree in developmental biology. He studied limb regeneration in salamanders and owes his scientific reasoning to his advisor, Dr. Roy Tassava, who taught him how to think and rationalize. Dale has spent his entire career with the Ohio Bureau of Criminal Identification and Investigation (BCI), a division of the Attorney General's Office. He has witnessed and been a part of the evolution of forensic biology from ABO and genetic markers to DNA. He has authored or co-authored 12 papers, presented 20 papers, has given numerous workshops on the use of luminol, and has lectured on a wide variety of forensic topics. He is a member and past president of the Midwestern Association of Forensic Scientists (MAFS) and a Fellow of the American Academy of Forensic Sciences. He was named Ohio Peace Officer of the Year in 1988, received the Superintendent's Award from BCI in 2004, and was recently given the Distinguished Service Award from MAFS, their highest honor. He dedicates his chapter on luminol to his wife Denise, for her encouragement and support, and to their sons, David and Kevin, for their assistance in his experiments.

Britton L. Mitchell is a Law and Science Fellow for the National Clearing House for Science, Technology and the Law. She graduated *magna cum laude* from Stetson College of Law and is an active member of the Florida Bar. She also received a B.S. degree in Accounting from Florida State University and a B.S. in Economics from Brigham Young University.

Marie Elena Saccoccio is an alumna of New England School of Law and Yale Law School and is a practicing attorney in Cambridge, Massachusetts concentrating on appellate/post-conviction matters. She is admitted to the bars of Colorado, Florida and Massachusetts where she works as a sole practitioner. She is the former judicial law clerk to the Honorable Wade Brorby of the United States Court of Appeals for the Tenth Circuit.

Robert P. Spalding served in the FBI for 28 years as an investigative Special Agent in Cleveland and at the Forensic Science Research and Training Center (FSRTC) in Washington, DC and the FBI Academy. In 1993 he was assigned to the newly formed Evidence Response Team (ERT) Unit where he taught crime scene investigation to FBI field office personnel. In this assignment, he also taught bloodstain pattern analysis to field FBI Evidence Response Team Personnel at the FBI Academy. Spaulding received his B.S. and M.S. degrees from the University of Maine in 1965 and 1968 respectively. He is currently a member of several professional organizations and is the owner of Spalding Forensics, LLC, a consulting and training firm in Centreville, Virginia, specializing in casework involving bloodstain patterns and crime scene reconstruction.

Ronald K. Wright is a forensic pathologist in private practice. He has a B.S. in Biology and Chemistry from Southwest Missouri University, an M.D. from St. Louis University School of Medicine and a J.D. from the University of Miami School of Law. He has practiced as a forensic pathologist and toxicologist for more than 30 years, holding positions of Deputy Chief Medical Examiner of the State of Vermont and Miami-Dade County Florida and Chief Medical Examiner of Broward County, Florida.

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Contents

Introduction to Bloodstain Pattern Analysis

1

Introduction

Blood is one of the most significant and frequently encountered types of physical evidence associated with the forensic investigation of death and violent crime. The identification and individualization of human bloodstains have progressed over the past 100 years since the ABO grouping system was discovered by Landsteiner in 1901. The techniques for the individualization of human blood in forensic science relied on the ABO system for many years. The development of the characterization of the red cell isoenzymes and serum genetic markers in the late 1970s dramatically increased the individualization of human blood. The work of Sir Alec Jeffreys in the development of DNA profiling in 1985 was a milestone in forensic science. Since then the techniques of DNA analysis in forensic cases has rapidly evolved through PCR (polymerase chain reaction) and STR (short tandem repeat) techniques and afforded the forensic scientist a powerful tool for the individualization of human blood. Bloodstains collected from a scene of violent death where bloodshed has occurred and blood samples collected from clothing of the victim and the accused can now provide a link between an assailant and a victim to a high degree of scientific certainty.

The identification and individualization of human blood is cojoined with the discipline of bloodstain pattern analysis (BPA). BPA focuses on the analysis of the size, shape, and distribution of bloodstains resulting from bloodshed events as a means of determining the types of activities and mechanisms that produced them. This information coupled with DNA individualization and wound interpretation from the autopsy examination of the victim by the forensic pathologist provides a basis for the reconstruction of the bloodshed events. The scientific analysis of bloodstain pattern evidence has proved crucial in numerous cases where the manner of death is questioned and the issue of homicide, suicide, accident, or natural death must be resolved in a criminal or civil litigation or proceeding.

Objectives of Bloodstain Pattern Analysis

BPA is a discipline that uses the fields of biology, physics, and mathematics. BPA may be accomplished by direct scene evaluation and/or careful study of scene photographs (preferably color photographs with measuring device in view) in conjunction with detailed examination of clothing, weapons, and other objects regarded as physical evidence. Details

of hospital records, postmortem examination, and autopsy photographs also provide useful information and should be included for evaluation and study. In cases where a scene investigation is not possible and photographs must be relied on, detailed sketches, diagrams, reports of crime scene investigators, and laboratory reports should be available for review.

Relative to the reconstruction of a crime scene, BPA may provide information to the investigator in many areas.

- Areas of convergence and origin of the bloodstains
- Type and direction of impact that produced bloodstains or spatter
- Mechanisms by which spatter patterns were produced
- Assistance with the understanding of how bloodstains were deposited onto items of evidence
- Possible position of victim, assailant, or objects at the scene during bloodshed
- Possible movement and direction of victim, assailant, or objects at the scene after bloodshed
- Support or contradiction of statements given by accused and/or witnesses
- Additional criteria for estimation of postmortem interval
- Correlation with other laboratory and pathology findings relevant to the investigation

The goal of the reconstruction of the crime scene using BPA is to assist the overall forensic investigation with the ultimate questions that must be addressed, which include, but are not limited to, the following:

- What event(s) occurred?
- Where did the event(s) occur?
- When and in what sequence did they occur?
- Who was there during each event?
- Who was not there during each event?
- What did not occur?

Scientific Approach to Bloodstain Pattern Analysis

The approach to BPA must adhere to the scientific method and rely on the principles of biology, physics, and mathematics. Education in these areas is highly recommended. A combination of training through formal instruction, personal experimentation, and experience with actual casework is necessary before an individual acquires adequate proficiency in the analysis of bloodstain patterns to answer these types of questions. Contemporaneous experiments to duplicate specific patterns should be considered relative to a given case to support an analysis or conclusion. Some conservative speculation is permissible during the initial investigative stages of a case. However, final opinions, contents of a written report, and ultimate court testimony must be based on scientific fact with *no speculation*. All potential explanations should be explored thoroughly and recognized and acknowledged by the analyst. Analysis of bloodstains should be correlated with postmortem and laboratory findings in an investigation. For example, when an arterial spurt pattern is observed, the autopsy report should indicate a cut or breached artery in the victim. In those cases where an assailant as well as the victim produces bloodshed or where there are multiple victims, the individualization of the bloodstains by the forensic laboratory is critical. It is important to stay within the realm of that which can be

proven scientifically and not to overinterpret bloodstain evidence. This axiom particularly applies when the number of bloodstains is limited because a single or few small bloodstains do not often lend themselves to useful valid analysis. Conclusions based on crime scene photographs should be conservative when the investigator has not had the opportunity to examine the crime scene personally and must rely on the photographic documentation of others.

Historical Development

The study of bloodstain patterns and the consideration of the physical processes in which the distribution of these patterns can reconstruct details of activities at scenes of death and violent crime have recently emerged as a recognized forensic skill. Historically, bloodstain analysis has suffered through a long period of neglect, and as a result investigators in death cases frequently have not appreciated the very obvious information available from this forensic tool. Significant contributions have been made in this discipline as documented in the following timeline.

1895 Dr. Eduard Piotrowski The earliest known significant study in bloodstain interpretation that has been documented and preserved was done by Dr. Eduard Piotrowski, assistant at the Institute for Forensic Medicine in Krakow, Poland. His work, entitled *Uber Entstehung, Form, Richtung und Ausbreitung der Blutspuren nach Hiebwunden des Kopfes*, was published in Vienna in 1895 (Figure 1.1). Piotrowski recognized that "It is of the highest importance to the field of forensic medicine to give the fullest attention to bloodstains found at the

Figure 1.1 The 1895 Eduard Piotrowski published study, *Concerning Origin, Shape, Direction and Distribution of the Bloodstains following Head Wounds Caused by Blows.*

scene of a crime because they can throw light on a murder and provide an explanation for the essential moments of the incident." Through the efforts of Herbert Leon MacDonell of Corning, New York, the Historian for the International Association of Bloodstain Pattern Analysts, this work has been translated from the German text and reprinted in German and English as *Concerning Origin, Shape, Direction and Distribution of the Bloodstains following Head Wounds Caused by Blows.* This work is completely reproduced with color plates of the extensive bloodstain experiments performed by Dr. Piotrowski. According to MacDonell, "No one preceded Piotrowski in designing meaningful scientific experiments to show blood dynamics with such imagination, methodology and thoroughness. He had an excellent knowledge of the scientific method and a good understanding of its practical application to bloodstain pattern interpretation."

1900 Dr. Paul Jeserich Subsequent significant work involving the study of bloodstain patterns at a crime scene is documented by Dr. Paul Jeserich, a forensic chemist in Berlin who examined homicide scenes during the first decade of the 20th century.

1939 Dr. Victor Balthazard The French scientist Dr. Victor Balthazard and his associates conducted original research and experimentation with bloodstain trajectories and patterns and presented a paper at the 22nd Congress of Forensic Medicine entitled *Etude Des Gouttes De Sang Projete*. This was translated from French to English as *Research on Blood Spatter.*

1955 Dr. Paul Kirk Dr. Paul Kirk of the University of California at Berkeley prepared an affidavit regarding his findings based on bloodstain evidence to the Court of Common Pleas in the case of the *State of Ohio vs. Samuel Sheppard.* This was a significant milestone in the recognition of bloodstain evidence by the legal system. Dr. Kirk was able to establish the relative position of the attacker and victim at the time of the administration of the beating.

1971 Herbert Leon MacDonell The further growth of interest and use of the significance of bloodstain evidence is a direct result of the scientific research and practical applications of bloodstain theory by Herbert Leon MacDonell of Corning, New York (Figure 1.2). Through the assistance of a Law Enforcement Assistance Administration (LEAA) grant, MacDonell conducted research and performed experiments to re-create and duplicate bloodstain patterns observed at crime scenes. This resulted in his publication of the first modern treatise on bloodstain analysis, entitled *Flight Characteristics and Stain Patterns of Human Blood* (Figure 1.3).

1973 First Formal Bloodstain Training Course Given MacDonell established a training program for basic bloodstain pattern interpretation and conducted his first Bloodstain Institute in Jackson, Mississippi in 1973. His second publication, *Laboratory Manual on the Geometric Interpretation of Human Bloodstain Evidence*, was used by students. Since that time he and others have conducted numerous basic and advanced bloodstain analysis courses throughout the United States and abroad and trained hundreds of police and crime scene investigators, forensic scientists, and crime laboratory personnel.

I982 *Bloodstain Pattern Interpretation* Published MacDonell expanded his original work in a publication entitled *Bloodstain Pattern Interpretation.*

1983 Formation of the IABPA MacDonell conducted the first advanced class for BPA, and the participants organized the International Association of Bloodstain Pattern Analysts (Figure 1.4).

Figure 1.2 Professor Herbert Leon MacDonell.

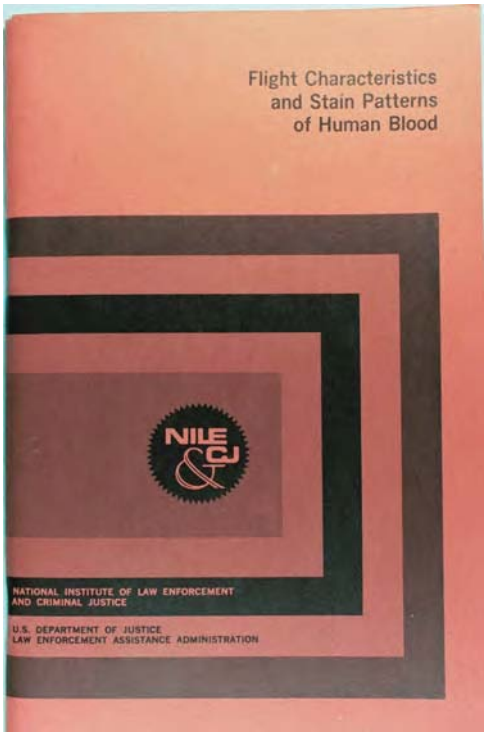

Figure 1.3 Copy of *Flight Characteristics and Stain Patterns of Human Blood*, written by Professor Herbert Leon MacDonell, that was published in 1971.

Figure 1.4 The International Association of Bloodstain Pattern Analysts logo.

***Experiments and Practical Exercises in Bloodstain Pattern Analysis* Published** Terry L. Laber and Barton P. Epstein cowrote a laboratory manual entitled *Experiments and Practical Exercises in Bloodstain Pattern Analysis* for use in their basic bloodstain analysis courses.

1989 *Interpretation of Bloodstain Evidence at Crime Scenes* Published The first edition of the book *Interpretation of Bloodstain Evidence at Crime Scenes*, written by Dr. William G. Eckert and Stuart H. James, was published. This work included numerous case studies involving BPA.

1990 *Bloodstain Pattern Analysis — Theory and Practice* Published Ross Gardner and Tom Bevel cowrote a laboratory manual entitled *Bloodstain Pattern Analysis — Theory and Practice.*

1993 *Bloodstain Pattern Analysis in Violent Crimes* Published T. Paulette Sutton at the University of Tennessee in Memphis produced a comprehensive manual entitled *Bloodstain Pattern Analysis in Violent Crimes.*

1993 *Bloodstain Pattern Interpretation* Updated to *Bloodstain Patterns* MacDonell updated his original bloodstain pattern manual *Bloodstain Pattern Interpretation* and renamed it *Bloodstain Patterns.*

1997 *Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction* Published Tom Bevel and Ross M. Gardner cowrote the text entitled *Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction.*

1998 *Scientific and Legal Applications of Bloodstain Pattern Analysis* Published Edited by Stuart H. James, *Scientific and Legal Applications of Bloodstain Pattern Analysis* was a compilation of chapters concerning bloodstain analysis and legal issues written by Dr. Alfred Carter, William Fischer, Carol Henderson, Paul Kish, Marie Saccoccio, and T. Paulette Sutton.

2001 *Blood Dynamics* Published Anita Wonder wrote the text entitled *Blood Dynamics* in 2001.

2004 Herbert Leon MacDonell Received Honorary Degree MacDonell received the honorary degree of Doctor of Science from the University of Rhode Island in recognition of his contributions to forensic science and BPA.

As a direct result of MacDonell's efforts, the evolution of bloodstain analysis in forensic science increased rapidly and others have made considerable contributions to the field in crime scene reconstruction, teaching, research, and publications.

Scientific articles pertaining to aspects of BPA are being seen more frequently in the scientific literature in well-known publications including the *Journal of Forensic Sciences, Forensic Science International,* the *American Journal of Forensic Medicine and Pathology*, the *Journal of the Canadian Society of Forensic Science*, and the *Journal of Forensic Identification.*

International Association of Bloodstain Pattern Analysts

As of 2004, the IABPA organization consisted of more than 750 members from throughout the United States and Canada as well as countries throughout the world including Great Britain, Denmark, Finland, Sweden, Norway, the Netherlands, New Zealand, Australia, Taiwan, Guam, and Columbia. The association publishes the *IABPA News*, which is devoted to current bloodstain topics, providing a schedule of training courses and exploring such issues as the curriculum for basic instructional courses in bloodstain interpretation, uniformity in bloodstain terminology, and research in the field. The annual IABPA conference agenda includes numerous case presentations and research topics by members and guest lecturers.

Classification of Bloodstains

The conventional method of classifying bloodstains was based on the correlation between the velocity of the force influencing the blood source or drop that governed the characteristics and size or diameters of the resulting bloodstains. Three basic categories of stain groups were used based on the concept that the size of the bloodstain being inversely proportional to the force applied to the static blood.

Low-Velocity Impact Blood Spatter

Low-velocity impact spatters (LVIS) are bloodstains created when the source of blood is subjected to a force with a velocity up to 5 ft/sec. Primary stains measure generally 4 mm in diameter or greater.

Medium-Velocity Impact Blood Spatter

Medium-velocity impact spatters (MVIS) are bloodstains created when the source of blood is subjected to a force with a velocity in the range of 5 to 25 ft/sec. The diameters of the resulting stains are in the size range of 1 to 3 mm, although smaller and larger stains may be present. Stains in this category were usually associated with beatings and stabbings.

High-Velocity Impact Blood Spatter

High-velocity impact spatters (HVIS) are bloodstains created when the source of blood is subjected to a force with a velocity of greater than 100 ft/sec. The diameters of the spatters

are predominately less than 1 mm, although smaller and larger stains are often observed within the pattern. Stains in this category were usually associated with gunshot injuries. Other mechanisms that produced stains within the size range of the conventional medium- and high-velocity categories such as satellite spatter and expiratory bloodstains were not appreciated to the extent that misinterpretations could and did occur.

Many bloodstain analysts have chosen to discontinue this conventional terminology and classification for a more holistic approach to bloodstain classification. The issues that kindled the rethinking of the conventional classification of low-medium-high velocity were the overlapping of stain sizes between the medium- and high-velocity categories and the realization that mechanisms other than beatings, stabbings, and gunshots frequently produced stains with size ranges within these categories. The bloodstains and patterns are classified based on their physical features of size, shape, location, concentration, and distribution into *passive stains, spatter stains,* or *altered stains.* They are further classified relative to mechanisms that may produce stains with those characteristics with reference to pertinent scene, medical and case related facts, and history of the evidence. The analyst may then be able to establish the specific mechanism(s) by which the pattern was created.

Acceptance within the Scientific Community

The reliability of scientific evidence must be addressed within the forensic science community including the discipline of BPA. The courts make a preliminary determination of relevance and admissibility of scientific evidence as to whether it is relevant, competent, and properly applied to the facts of the case. So-called "pseudoscience" has no place in the judicial process. This is referred to as the "gatekeeping" function of the court. Some states apply the Frye standard, although many apply the Daubert standard. The interpretation of a Frye inquiry is to determine whether or not the procedure, evidence, or proposed testimony is relevant and has gained general acceptance within the scientific community. Daubert substitutes a reliability test for a relevancy test. Scientific knowledge must be derived from the scientific method supported by validation of expert testimony establishing a standard of evidentiary reliability. The factors for Daubert are outlined as follows:

- Has the scientific theory or technique been empirically tested?
- Has the scientific theory or technique been subjected to peer review and publication?
- What is the known or potential error rate?
- What are the expert's qualifications and stature in the scientific community?
- Can the technique and its results be explained with sufficient clarity and simplicity so that the court and the jury can understand its plain meaning?

Scientific Working Group for Bloodstain Pattern Analysis

The Federal Bureau of Investigation (FBI) Laboratory has actively organized and funded Scientific Working Groups (SWG) to establish professional forums composed of experts from local, state, federal, and international agencies as well as academic scientists and private practitioners to address issues within specific forensic disciplines. The Scientific Working Group on Bloodstain Pattern Analysis (SWGSTAIN) was established, and the first meeting was held at the FBI Academy in Quantico, Virginia in March 2002. Recognized

bloodstain pattern analysts and practitioners in related fields from North America and Europe convened to discuss and evaluate methods, techniques, protocols, quality assurance, education, and research relating to BPA. The group meets biannually. Subcommittees were established in the following areas:

- **Education and Training.** This subcommittee addresses educational standards for students and instructors as well as standards for continuing education.
- **Legal.** This subcommittee addresses issues of scientific acceptance, peer review, publications, error rates, and existence of standards.
- **Quality Assurance.** This subcommittee addresses issues of report writing, proficiency testing, methodology, and standard operating procedures.
- **Research.** This subcommittee addresses issues of development of new methodologies, standards, resources, references, and validation.
- **Taxonomy and Terminology.** This subcommittee addresses taxonomy, glossary, and definitions.

Education and Training in Bloodstain Pattern Analysis

Bloodstain analysts represent a range of forensic scientists and crime scene investigators with diverse levels of education. The courts have accepted testimony from individuals with strong backgrounds in chemistry, biology, and physics. Many of these individuals possess degrees in science and/or forensic medicine. Many of these individuals are employed in crime laboratories or medical examiner offices that have crime scene responsibilities. Crime scene investigators, evidence technicians, and detectives who do not necessarily possess scientific backgrounds have also offered expert testimony. However, college-level courses in geometry, trigonometry, and basic physics are valuable assets for the understanding of BPA.

It is highly recommended that individuals enroll in a basic 40-hr course in BPA. These courses are usually taught over a 5-day period and occasionally as a semester course at a college or university by qualified instructors at numerous locations in the United States and abroad. They provide instruction in the theory and practical aspects of BPA, case presentations, and opportunities to perform laboratory experiments. Participation in laboratory experiments is crucial for understanding the dynamics of bloodstain pattern production and the mechanisms involved. Students create stain patterns similar to those present at crime scenes using various types of apparatuses. Patterns are created on cardboard and other surfaces that may be preserved and retained for future reference.

Advanced courses are also available following the successful completion of a basic course. The advanced courses are designed to review basic concepts and provide additional training in areas not explored in the basic courses. For example, an advanced course may concentrate on computer analysis; digital imaging; examination of bloodstained clothing and footwear; mock crime scenes; and, in some cases, mock trials. Students are encouraged to present cases to the group for peer review sessions. Successful completion of basic and advanced courses in BPA does not imply that an individual is a qualified bloodstain analyst. The formal education must be coupled with years of experience with crime scenes and evidence examinations along with regular attendance at scientific seminars or conferences. It is also important to stay abreast of the information in scientific journals and periodicals.

Membership in professional organizations is encouraged. Students who have successfully completed a basic course in BPA are qualified to apply for membership in the IABPA.

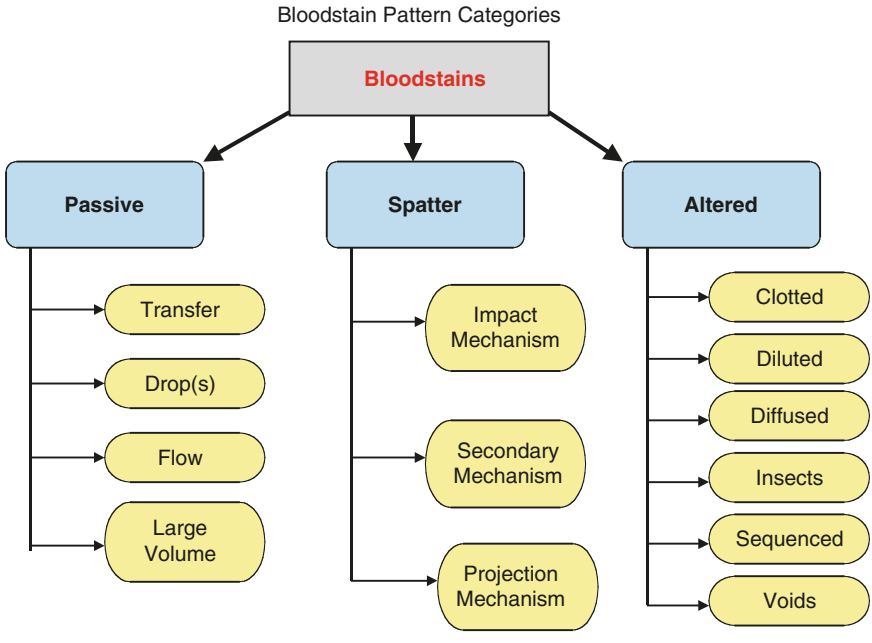

Figure 1.5 Bloodstain pattern categories.

Conclusion

The taxonomic approach to the classification of bloodstains and patterns is not entirely new. It has been discussed among bloodstain pattern analysts for a long time and has been described to varying extents in several texts published within the past ten years. The hierarchy of bloodstain categories that are discussed in this text combines the geometric characterization of the bloodstains with the events that caused the bloodstains (Figure 1.5). The objective is to strengthen the scientific process of BPA in actual casework through the ultimate test in the legal process and the courts. The variable level taxonomic classification is not complex but addresses the issue of the mechanisms that produce overlapping patterns with respect to the size of the stains. The structure of the categories will permit the analyst to begin with the primary bloodstain pattern categories — namely, passive, spatter, and altered — and proceed to specific subcategories based on case-driven facts.

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Appendix D: Biohazard Safety Precautions

Figure D.1 Personal protective equipment (PPE) decision tree.

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