THE FORENSIC SCIENCES FOUNDATION, INC.
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RESEARCH FINDINGS FOR FORENSIC INFORMATION USERS

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TABLE OF CONTENTS

INTRODUCTION

Forensic Science, by definition, is the application of scientific knowledge, principles and techniques to the resolution of legal issues. What makes Science "forensic" is its use by the justice system. For the justice system to make maximum use of forensic science, the users of this information--judges, attorneys and law enforcement personnel--must have an understanding of the current capabilities and limitatious of forensic science and the critical issues which impact on its future.

To this end, leading figures in six major forensic science disciplines have written comprehensive yet succinct chapters describing the state of the art of their respective disciplines.

This document addresses Criminalistics, Forensic Odontology, Forensic Pathology, Forensic Anthropology , Questioned Document Examination and Forensic Toxicology. It is intended that these chapters will provide decision makers in the justice system with the requisite information to better understand utilize and maximize the forensic sciences.

The format of each chapter will provide the reader with an understanding of the

- Definition and Scope of the Discipline
- Current Capabilities and Limitations
- Developing Areas
- Critical Issues
- Glossary of Terms
- Bibliography

ACKNOWLEDGMENTS

The six chapter authors and Forensic Sciences Foundation staff wish to express their thanks to the staff of the National Institute of Justice, especially to our first project monitor, John L. Sullivan (deceased) and to our current monitor Joseph Kochanski for their foresight in recognizing the need--by the users of forensic science services--for such a publication.

Thanks are also owed to the members of the Editorial Review Board for their study and critique of the chapters contained herein: Oliver C. Schroeder, Jr. (Chairman), Honorable James W. Dolan, George W. O'Connor, E.J. Salcines, James E. Starrs.

EXECUTIVE SUMMARY

I. PROJECT OBJECTIVE

The ultimate objective of this project is to improve the quality and quantity of forensic sciences used in the legal system ... by assisting police, attorneys, prosecutors and judges in understanding and using these services to their greatest advantage.

The final product, in achieving this goal, is a state-of-the-art manual written in non scientific language which not only covers what the forensic sciences can do but also what the profession cannot do.

II. BACKGROUND

A. Selection of Disciplines

Initially, seven disciplines were selected for coverage in this manual: Criminalistics, Document Examination, Forensic Odontology, Forensic Pathology, Forensic Physical Anthropology, Forensic Psychiatry and Forensic Toxicology.

However, in the course of project execution it became evident that of the list of forensic psychiatrists desired as authors none were available ... all being heavily involved in the "Hinckley Case". Accordingly, the project monitor, John Sullivan, directed that the forensic psychiatry chapter be deleted.

B. Selection of Authors

The process of author selection was accomplished in concert by the Forensic Sciences Foundation and by the Project Monitor, John O. Sullivan.

Criteria for selection included:

. Acknowledged Authority in the Field

. Writing Experience

. Availability

The product of this evaluation resulted in offers being extended to and accepted by the following to author individual chapters:

. Criminalistics - John I. Thornton, D. Crim.

. Forensic Document Examination - Maureen A. Casey, A.B.

. Forensic Odontology - Lowell J. Levine, D.D.S.

. Forensic Pathology - James T. Weston, M.D. (Deceased)

. Forensic Physical Anthropology - Ellis R. Kerley, Ph.D.

. Forensic Toxicology - Bryan Smith Finkle, Ph.D.

. Forensic Psychiatry - Park E. Dietz, M.D., M.P.H. (Subsequently withdrawn)

C. Selection of Editorial Review Board Members

The major factor considered in the selection of members to serve on the Editorial Board was broad representation by users of forensic science services ... to ensure that the end product met the requirement to write in lay language.

Following are the members of that board, approved by the project monitor, John O. Sullivan.

Editorial Review Board

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III METHODOLOGY

A. General

It was recognized that the initial step required the development of a comprehensive, common outline format for the chapters.

The format was prepared by project staff and subjected to review by the Project Monitor and the Editorial Review Board.

B. Chapter Format

I. Definition, Nature and Scope of The Discipline.

In essence, this section serves the purpose of an executive summary -- a concise summary of the material contained in subsequent sections.

a. Present an academic definition of the discipline.

b. Develop a practical or working definition for the reader.

c. Briefly summarize current capabilities and limitations.

d. Summarize developing areas and critical issues.

II. Current Capabilities and Limitations.

a. Description.

Describe each capability, by logical categories.

b. Overview

In content with para a., above, present an overview of widely accepted scientific procedures and techniques.

c. Investigative Results.

Discuss, in terms of product or service, the significance of results obtained -- to include the degree of scientific precision attained, variances and their causes, and the statistical significance of specific results.

d. Limitations.

Describe limitations in terms of and unique to procedures, facilities, equipment, expendable supplies, other resources, personnel, education and training, organization, and other systemic factors, and legal constraints.

III. Developing Areas

Identify and discuss emerging techniques, methodologies in which work is progressing to provide new and/or increased capabilities.

IV. Critical Issues.

Identify issues, problem areas affecting the discipline, professionals within the discipline and users of the discipline.

V. Legal Citations.

Provide a summary of legal citations, references, etc. pertaining to the discipline.

VI. Bibliography.

Provide a comprehensive bibliography of relevant references and sources within the discipline.

C. Comprehensive Outlines

Next, each author submitted a comprehensive chapter outline which was also reviewed by the Project Monitor and the Editorial Review Board for its compliance with the format and completeness.

Each outline was submitted to the Project Monitor, as completed, where they were also given a comprehensive review before approval...an extraordinarily time consuming process.

D. Draft Chapters

The third step involved completion and submission of draft chapters. The chapters were reviewed, in depth, at a two day meeting of the Editorial Review Board. This meeting produced concrete editorial suggestions which were communicated to the authors who, in turn, incorporated them into their respective chapters. These suggestions included expanded glossaries, significant cases, and topic coverage.

E. Editing

The revised draft chapters were edited for commonality of form, writing style and grammar.

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CRIMINALISTICS

By

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EXECUTIVE SUMMARY

Criminalistics is the profession concerned with the analysis, identification, and interpretation of physical evidence. The principal role of the criminalist is to apply in an objective manner those elements of the natural and physical sciences that are relevant to the nature of the evidence under consideration; the ultimate aim is to identify material, to aid in the reconstruction of the crime, or to establish an element of the crime necessary for the proper adjudication of the matter.

Because of the infinite variations in human activity surrounding a crime, there is no limitation as to the scope of physical evidence. In one case the evidence may be so small that a microscope is needed to see it, in another it may be as large as a truck. In still another case the evidence may be as subtle and intangible as a whiff of perfume in a closed room, and in yet another it may be as offensive as the odor of a decaying body.

The criminalist must be able to distinguish significant evidence from that having little or no probative value. He or she must then identify or individualize the evidence through the application of a protocol of analysis tooled to the particular needs of the case. In most instances, an attempt is made to determine the unique aspects of the evidence. This requires on the part of the criminalist a conversancy with many scientific disciplines, an affinity for detail, reasonably keen faculties of perception, an awareness of the goal to be achieved, and respect for the ethical responsibilities of the profession. The criminalistics enterprise also requires an understanding of physical causes and effects, knowledge of the physical laws and processes involved and recognition of their interactions, plus an understanding of human behavior. And lastly, the criminalist must convey his or her findings

to other elements of the criminal justice system. This is usually done by means of written reports, but it is also accomplished by means of oral testimony in court. The criminalist has an ethical responsibility to express his or her conclusions in such a manner that technical matters are understood clearly by the court and the jury.

The foregoing represents a lofty ideal which may be sincerely pursued but which, for a constellation of reasons, may not in actual practice be realized. Like most other segments of the criminal justice system, criminalistics functions well in some areas and less well in others. Both will be discussed in this chapter.

Depending upon one's perspective, criminalistics may be defined in either an additive or a subtractive manner. In a subtractive sense, criminalistics is what remains when the other more easily identified and cohesive forensic disciplines (e.g. forensic anthropology, forensic pathology, forensic toxology) are removed from the broad category of forensic science. In an additive sense, criminalistics is an amalgamation of a number of the natural and physical sciences, synthesized in such a manner as to address questions of physical evidence. The precise array of evidence categories may also depend somewhat on the perspective of the viewer, but ordinarily includes the examination of blood and other physiological fluids, fingerprint identification, the identification of drugs and narcotics, toolmark and firearms identification, and the examination of a farrago of materials broadly labeled "trace evidence," such as soil, paint, glass, gunshot residues, safe insulation, the restoration of serial numbers, explosive residues, hair, fibers, and other miscellaneous detritus. The array of physical evidence categories countenanced by the criminalistics enterprise is by no means static.

At the beginning of the 20th century, the criminalist would include in his repertoire interpreting the meaning and significance of tatoos on the bodies of criminals, whereas the criminalist of the 1980's, with little knowledge and less interest in tatoos, will be comfortable in the use of the laser or the scanning electron microscope.

Both the additive and subtractive definitions of the criminalistics discipline suffer a common defect, however. Both points of view focus upon the substrates, or the types of evidence analyzed by the criminalist, rather than the approach used in the conduct of his or her analyses. A case may hinge on the identification of peanut butter. There are for all practical purposes no experts on the identification of peanut butter. Looking in the index of any textbook on forensic science under "P" for peanut butter would be futile. At this point, the criminalist is a pilgrim and must rely on his or her virtuosity in applying a diverse set of scientific principles to this unique problem. What distinguishes criminalistics from high-grade detective work or the work of a technician is the ability to apply the scientific method in a felicitous manner; in every instance the approach to a physical evidence problem must pass muster according to criteria generally accepted not only within the criminalistics discipline but by the universal scientific community. This aspect of criminalistics is subtle, but essential, and is what makes it a discipline in its own right. Criminalistics is a serious scientific enterprise, crystallized from a number of convergent pathways for the express purpose of providing an objective examination of diverse materials.

In this application, the criminalistics profession is a rather uneven one. There is by no means unanimity as to the precise formulation of its function and how this function should be acted out. One prominent

forensic scientist has said that is like crabgrass - it infests a large area untidily and parasitically. This is probably true, and is compounded by the confusion arising from the fact that the goals set by the practicioners themselves are not in total accord with the goals assumed for the discipline by the users of the service, namely the police, attorneys, and the judiciary.

Criminalistics has developed in response to the needs of the legal system. The most obvious need is the use of physical evidence in a strictly investigative manner, but the need also exists for a way to present, describe, and interpret technical evidence clearly to a court or jury. The adaptation of the technological achievements of our age to the study of evidence is an attempt to meet these requirements. The problem is that the needs of the legal system have not been conveyed with clarity and precision so that criminalistics, as a synthetic discipline spawned to meet these needs, frequently suffers from the same lack of definition.

Further, criminalistics was spawned fairly recently. While man has been on the face of the earth for several million years, and crime probably just as long, science is only about 300 years old and crime laboratories are strictly a 20th century innovation. The term kriminalistik was coined by Hans Gross in 1893, but the first operational crime laboratory did not come into existence until 1910, when a laboratory was placed into operation in Lyon, France, by Edmond Locard. The first crime laboratory in the United States dates from 1923, and the first laboratory in Great Britain did not emerge until shortly before World War II.[1]

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[1] "Criminalistics - Past, Present, and Future," John I. Thornton, Lex et Scientia 11:1-44 (1975).

The profession is still experiencing some teething problems. One problem which has not yet been totally resolved is operational responsibility in those areas where some overlap exists between criminalistics and other forensic disciplines. For example, the identification of drugs in biological materials is ordinarily the domain of the forensic toxicologist, while the identification of street drugs is more commonly the chore of the criminalist. The identification of handwriting is clearly within the province of the questioned document examiner, yet many operational crime laboratories provide this service and call upon a criminalist to conduct these examinations. All too often forensic services have grown by happenstance rather than by design, but once institutionalized any adjustment of function becomes difficult.

Another dilemma not yet resolved is the generalist versus specialist conflict which arises partly out of a philosophical stance and partly out of the reality of staffing considerations. In larger laboratories the division of responsibility may mean that a person becomes a specialist in a given evidence category such as drug identification or serology. In the extreme case, the laboratory may be a pastiche of serologists, chemists, geologists, metallurgists, and the like, each with a closer affinity to the parent discipline than to the more broadly constituted doctrine of criminalistics. A chemist hired to conduct drug analyses and drug analyses only may have the job title of criminalist, but will generally perceive of himself as a chemist rather than a criminalist. In the generalist approach, the criminalist may not have the in-depth knowledge of the specialist in any given area but by virtue of a broader exposure can select pertinent aspects from several disciplines to clarify the issue at hand. Dangers exist in either category. The specialist may ignore or destroy one potentially valuable type of evidence

because of his or her haste to apply the techniques of the speciality. The generalist may not be sufficiently clever in a narrow, restricted area to derive the maximum information available from the evidence. The optimum probably lies somewhere in between, but the precise admixture of the two doctrines has not yet been determined. There is, however, an undeniable trend in the United States toward the specialist concept.

Any attempt to describe the state of the criminalistics art must necessarily include a discussion of current capabilities and limitations. A subsequent section of this chapter will summarize these. It must be stressed here, however, that the capabilities of criminalistics are determined primarily by scientific factors, while its limitations are frequently determined by various factors unrelated to science. The real constraints are extraneous limits placed on the laboratory in its attempt to fulfill its designated function. These constraints include: ineffective coordination between the evidence recovery process and the evidence analysis process, an inability of the criminalistics discipline to articulate and communicate its needs and concerns to the appropriate elements of the criminal justice system, burdensom caseloads tending toward a superficial treatment of some evidence categories, budgetary restrictions, and a lack of awareness and understanding of the criminalistics enterprise on the part of law enforcement executives, attorneys, and the judiciary.

Up to this point, the picture of criminalistics today has been rather dark. But there is a brighter side. Much good work emanates from the nation's crime laboratories, and the criminalistics profession can take justifiable pride in numerous technological advances and in many elegant solutions to complex problems. Among these, to be discussed later, are a number of recently

developed approaches to the examination of bloodstains and stains of other physiological fluids, the development of an antibody to a semen-specific protein for use in cases of sexual assault, the use of the argon ion laser for the development of latent fingerprints and the reconstruction of fractured glass, and the development of a number of techniques for the determination of gunshot residues on the hands and clothing of a person suspected of having handled or discharged a firearm.

CURRENT CAPABILITIES AND LIMIATIONS

A brief summary of the current capabilities and limitations relative to the various major categories of physical evidence will be presented here. It should be recognized, however, that entire textbooks have been written concerning each of these subjects and that the treatment here is necessarily superficial. It should also be stressed that any statement made here or elsewhere concerning the capabilities or the limitations of examinations of particular types of physical evidence may be rendered instantly incorrect because of some new advancement. Such advancements take place continuously.

Blood Evidence

It is, of course, possible to determine if a stain is blood as opposed to some other red material. Presumptive chemical tests and confirmatory micro-crystalline tests for blood depend on the demonstration of heme. The tests are highly specific but are not entirely accurate as false positive reactions are given by some bacteria. Testing of this sort can be accomplished on an exceeding small amount of blood, something on the order of a spot the size of a flyspeck.

The so-called precipitin test, in one of its various forms, is then performed to determine if the stain is human blood, or, if not human blood, what animal did shed the blood. This test requires a very small sample also. If the precipitin test demonstrates that the sample is indeed human blood and if enough of the sample remains, the blood may be characterized further by other tests, thus narrowing the field of possible donors.

From a stain roughly the size of a dime numerous blood types can be determined. In the past two decades, enormous strides have been made in the area of forensic serology, and many of the genetic markers in blood are now

determined concomitantly. The most well-known of these genetic markers is the ABO system, which divides the population into four categories:

ABO System

Type	% of population
A	40
B	10
AB	5
O	45

The frequency of occurrence in the population given here are approximate and will vary somewhat depending upon the racial mix of the population. There are many more genetic markers in blood than just the ABO system, however. Since these markers are inherited independently and since their frequency of occurrence in the population is known, a profile of genetic markers permits a calculation of the uniqueness of any given combination of types in a bloodstain. The markers routinely determined in addition to the ABO system are the GC type, the Haptoglobin type, and the following isoenzyme types: Phosphoglucomutase (PGM), Esterase D (EsD), Adenylate Kinase (AK), Glyoxase I (GLO I), Adenosine Deaminase (ADA), and Erythrocyte Acid Phosphatase (EAP). The frequency of the various subdivisions of these markers occurs as follows:

ABO		PGM		EAP	
A	(.40)	1-1	(.60)	AA	(.11)
B	(.10)	2-1	(.35)	BA	(.41)
AB	(.05)	2-2	(.05)	CA	(.03)
O	(.45)			BB	(.38)
				CB	(.07)

Hp		EsD		ADA	
1-1	(.18)	1-1	(.79)	1-1	(.90)
2-1	(.50)	2-1	(.19)	2-1	(.10)
2-2	(.32)	2-2	(.01)	2-2	(.003)

GLO I		AK		Gc	
1-1	(.16)	1-1	(.92)	1-1	(.55)
2-1	(.48)	2-1	(.08)	2-1	(.38)
2-2	(.36)	2-2	(.002)	2-2	(.07)

An example of the characterization of a bloodstain and the frequency of the combination is given by the following:

ABO	PGM	EAP	EsD	Hp	GLO I	Gc	AK	ADA
A	1-1	BA	1-1	2-2	2-1	2-1	1-1	2-1

.40 x .60 x .41 x .79 x .32 x .48 x .38 x .92 x .10 = 0.0004

With this hypothetical bloodstain, only about 4 people in 10,000 would be expected to have the same array of types. If one multiples together all of the most common factors (Type O, PGM 1-1, EAP BA, and so on) one obtains a value of 0.009 (9 people in 1,000 would be expected to have the same types). If one multiplies together the least common types (Type AB, PGM 2-2, EAP CA, and so on) one obtains a probability of chance occurence of one in 100 trillion.

The Rh, or Rhesus types, may be demonstrated in dried bloodstains but with difficulty. There is some controversy concerning another system, the MN system, but many forensic serologists consider this system to be treacherous when applied to dried bloodstains and do not attempt to determine MN type.

The presistence of genetic markers in dried bloodstains varies greatly among the various systems. The ABO system will persist indefinitely. The practical difficulties of testing for Rh types are far greater than with the ABO system, with much larger quantities of bloodstain being required, and the types deteriorate rapidly after about six weeks. Haptoglobin may persist for several years, PGM for 2 to 4 months, EAP for 3 to 6 weeks, AK for about 6 months, ADA for 3 to 4 weeks, GLO I for 2 to 4 weeks, and EsD for 1 to 3 weeks. The above values assume that the stain is kept at room temperature; freezing the stain will permit the determination of blood types for a much longer period of time.

It may be possible under some circumstances to determine if a stain is menstrual blood and to determine sex from a bloodstain, although these tests are not routinely conducted at the present time. It may also be possible under some limited circumstances to determine the age of a bloodstain, although this subject must be approached with considerable diffidence.

It is frequently possible, by an observation of the pattern or distribution of bloodstains, to reconstruct the manner in which the blood was distributed during the crime. From this, it is possible to deduce such information as the relative positions of assailant and victim, and what type of weapon was used, if any.

Seminal Stains

It is possible to determine if a suspected stain is seminal fluid by means of a microscopic examination for spermatazoa, analyzing for acid phosphatase (which is not a specific test), and by the use of anti-p30 serum (which is). In some instances, it is possible to determine genetic markers in seminal fluid, the principal markers being the ABO system, the PGM type, and GLO I. If the seminal fluid is mixed with vaginal secretions, however, confusion may result in the interpretation of test results, and the typing of mixture stains must therefore be interpreted conservatively.

Other Physiological Fluids

It is generally possible to determine the nature of other biological stains, such as saliva, urine, perspiration, and feces. It is occasionally possible to determine the ABO type of these stains, although the ability of the criminalist to determine the type is much more limited than with blood and seminal fluid.

Fingerprint Evidence

Fingerprint evidence represents the ultimate in personal identification. A demonstration of spatial accord in the minutiae of fingerprints will establish an unequivocal identification of an individual, to the total exclusion of all other persons on earth. There has been little fundamental research into the uniqueness of fingerprints since the beginning of the 20th century, and much of our knowledge of fingerprint individuality has been developed empirically. Recent developments connected with fingerprint evidence have for the most part been restricted to the development of latent fingerprints on the bodies of homicide victims and the development of latent prints on a variety of materials by means of the argon ion laser. Despite the lack of a comprehensive model to explain the uniqueness of fingerprints, it is likely that fingerprints will continue to represent the probative standard against which all other identification methods will be measured.

Hair Evidence

It is generally possible to determine the species of animal from an examination of a hair under the microscope, although this requires a skill on the part of the examiner which is frequently absent. It is generally not possible to distinguish closely related species, such as deer and elk or cat and leopard. It is not possible to determine if a particular hair originated from a particular animal or person. If all of the features observable under the microscope are in close agreement, the strongest statement that can be made is that two hairs are consistent with having shared a common origin. The instrumental techniques dealing with trace elemental composition of hair as a parameter of identification that were advocated in the early 1960's have been shown to have serious limitations for forensic purposes. Controlled

studies have shown that the ABO blood groups may be found in hair; however, no universally reliable technique has been developed for their determination. The statistical techniques that have been proposed for the interpretation of hair evidence are defective from one point or another, and there is a pronounced decline in the application of statistical approaches to hair identification.

Fiber Evidence

As with hair evidence, the examination of fibers is carried out at two levels, identification and comparison. Although the distinction between the two levels is not altogether distinct, the former addresses the question of the determination of the generic type of the fiber while the latter presumes that the fibers being compared are of the same type. Microscopic and instrumental tests for the identification of fibers are quite sophisticated, and it is generally possible to identify the type of fiber from a very small sample. In a comparison mode, it may be possible to show that two fibers are of the same generic type (e.g. the same polymer), that they are of the same diameter and color, and in some instances it may be possible to show by pyrolysis gas chromatography that they were produced by the same manufacturer. With agreement in all of these characteristics, the strongest conclusion that can be rendered is that the fibers are consistent with having shared a common origin; only when it is evident that a physical match exists in torn threads in a fabric will it be possible to state that the evidence and the known fibers did in fact originate from the same source.

Toolmark Evidence

Toolmarks are encountered in two forms, as compression marks and as striated impressions. Compression marks are basically dent marks, and

frequently do not embody sufficient individuality to determine other than the class characteristics of the tool, i.e., configuration and dimensions. Striated impressions are basically scratch marks, and generally provide sufficient individuality to establish a particular mark as having been made by a particular tool, to the total exclusion of all other tools.

It is possible for the same tool to leave both compression marks and striated marks; in such instances the principal value of the compression mark is to orient the tool relative to the surface so that test marks may be made more easily. The striated impressions are much more likely to result in an unequivocal identification of the tool as having made the evidence mark.

In a microscopic examination of evidence marks and test marks made with a suspected tool, there is no precise standard as to the number of matching striae needed for an identification. The criteria for a positive match is indeed subjective, and represents the projection of the extent of matching against a gestalt of past experience on the part of the examiner. These same comments would also be made in connection with the identification of bullets and cartridge cases fired in a particular weapon; the identification process is essentially the same, and in fact a bullet match may be considered as simply a special case of toolmark match.

Firearms Identification

The classical firearms identification question is whether a particular projectile or expended cartridge case was in fact fired through a particular firearm. This question, though frequently of crucial interest to an investigation, represents only one of an extended array of questions that a firearms examinaer is called upon to consider. Other questions can generally

be answered after a systematic examination of the evidence:

1. Is the firearm in proper operating condition? Does it have a hair trigger or can it be accidentally discharged by misadventure?
2. If the weapon is not available, will an examination of the projectile or expended cartridge case indicate what type of weapon (i.e. manufacturer and model) to search for?
3. What was the distance from the muzzle of the weapon to the target at the time the weapon was discharged?
4. Will a reconstruction of the bullet pathway establish the position of persons or objects at the time the weapon was discharged?
5. If the weapon has an obliterated serial number, can the original number be restored?
6. Is there evidence to indicate whether a person has recently discharged or handled a weapon?

Firearms identification represents an area that is constantly changing, as new weapons and types of ammunition are introduced. The techniques that are used to answer the questions above, however, are essentially the same techniques that have been used since their introduction in the late 1920's. An exception is in the area of gunshot residues, where considerable strides have been made within the last decade. Within limits, it is now possible to determine in many instances if a person has handled or fired a weapon by one of several techniques.

Glass Evidence

Glass evidence is compared on the basis of density, refractive index, dispersion, flourescence, and the presence of trace elements. If two samples of glass agree closely in these characteristics, it may be concluded that the samples are consistent with having shared a common origin or were made incidental to a common production process. It is generally possible

to determine the direction of force when a window is broken, and laser interferometry may assist in the reconstruction of fractured glass to determine if the fragments had at one time been joined.

Paint Evidence

Paint evidence is compared microscopically for such features as color, layer sequence, and layer thickness. Possibly to a greater extent than with most other types of evidence, instrumental analysis may be applied meaningfully to the analysis of paint evidence. This reflects in part the nature of the evidence and the diversity of manufacturing processes used in the production of paint. If a physical match of a fracture edge can be established between a known sample and an evidence fragment, it may be concluded that the evidence and the known sample had in fact shared a common origin. In the absence of a physical match, the strength of an opinion is directly related to the extent of matching in color, complexity of the layer structure, and elemental composition.

Soil Evidence

Soil evidence is compared first on the basis of color, and then on the basis of its behavior in a density gradient. Recently there has been a surge of activity on the part of many forensic laboratories to conduct examinations with the polarizing microscope to identify the constituent minerals. Although the technique has seen only limited application to date, it is possible to determine the complexion of enzyme activity in soil as a means of establishing the geographical location of the source of the sample.

Problem Areas

There are some technical areas that have defeated the collective

ingenuity of the criminalistics profession. There is at present no good way to characterize and compare the very low viscosity petroleum materials such as tar and asphalt. Hair is a biological material and therefore is probably more unique than can be established at the present time. There is at present no method to determine the age of a latent fingerprint, although this may change as a result of ongoing research by laser flourescence. Although techniques have been described for the sex determination of hair and dried bloodstains, the techniques will require additional refinement before they are suitable for routine application in actual casework.

DEVELOPING AREAS

In this section will be discussed a number of emerging techniques having the potential of providing new or increased capabilities. Most of the discussion will center around technical matters at the leading edge of the criminalistics enterprise. One area, however, is of a different sort. This area is concerned with laboratory accreditation, and has as its aim the maintenance of a "quality ethic" within the profession.

A number of the other forensic science disciplines have elected to certify individuals. Forensic pathologists, forensic anthropologists, forensic toxicologists, forensic odontologists, and questioned documents examiners have all gone the route of establishing national certification boards whose function it is to administer tests to determine the adequacy of a person's training and experience as it relates to the practice of the respective discipline.

The criminalistics profession has taken another tack, not of certifying individuals, but of accrediting laboratories. Under this program, which is just commencing as of the time of this writing, the American Society of Crime Laboratory Directors, with the assistance of the FBI, has appointed a number of experienced criminalists to conduct site visits of operational crime laboratories and recommend whether a laboratory should be accredited. The accreditation criteria include such factors as the formal education of the laboratory staff, the nature and quality of in-service training, attendance at formal courses of instruction given at the FBI's training facility at Quantico, and even such things as the suitability of known standards of trace evidence materials, e.g., hair standards, paint standards,

fiber standards, and the like, and the adequacy of library resources. It is far too early to evaluate the effectiveness of this accreditation program, but many professionals see in this program an opportunity to complement their existing quality assurance program with an extrinsic means of maintaining their technical competency.

The developing areas of a technical nature that will be discussed here involve horizon events in bloodstain identification, seminal fluid identification, soil identification, gunshot residues, automated drug testing and the use of the argon ion laser to develop fingerprints and to aid in the reconstruction of fractured glass.

Research in the area of bloodstain identification has progressed more rapidly in the past few years than has occurred in most other evidence categories. As outlined previously, the ability to detect an ensemble of genetic markers in a bloodstain does much to individualize the stain as having originated from a particular individual.

There is every indication, however, that the techniques now used by the forensic serologist will be subjected to further refinement to extend the process of individualization. A number of areas would appear to offer the promise of productive research.

Several genetic markers of the isoenzyme type are difficult to determine in dried bloodstains, but it is likely that further refinement of techniques will ultimately lead to their reliable determination. One of the more promising markers of this type is the isoenzyme Peptidase A (PEPA). There are technical difficulties in separating the so-called "8-types" of this system, but the problems are not insurmountable.

Several of the serum protein types of genetic markers show considerable promise. Transferrin (Tf) is a genetic marker occuring in blood and to a lesser extent in seminal fluid. The so-called TfC type has recently been subtyped by means of isoelectric focusing, but this technique has not yet been adapted for the typing of transferrin in dried bloodstains. It is likely that additional work will be attempted on this system, since transferrin appears to be more stable than some other genetic markers and may persist in dried bloodstains for a longer period of time. Other serum proteins which are not routinely determined in laboratories in the United States but which hold promise are the Gm or "Gamma marker" types and the Km or "Kappa marker" types. Most assuredly the book is not yet closed on forensic serology research in the 1980's.

One of the more promising areas in the identification of seminal stains has been the recent discovery of a protein specific to seminal fluid. Immunological tests for the demonstration of seminal stains have been around for a number of years, but all suffered from a lack of specificity of the antisera. In the late 1970's, however, Edward Blake at the University of California at Berkeley noted a protein on electrophoretic gels that was present in seminal fluid but absent in serum. George Sensabaugh, for whom Ed Blake was working at the time, subsequently isolated and characterized this protein, which he called p30.[2] An antiserum to this protein was developed by immunizing rabbits with the protein. The antiserum is now

[2] "Isolation and Characterization of a Semen-Specific Protein From Human Seminal Plasma: A Potential New Marker For Semen Identification," George F. Sensabaugh, J. For. Sci. 23:106 (1978).

commercially available and permits an unequivocal identification of seminal stains, even in the case of aspermic or vasectomized individuals. Anti-p30 does not react with vaginal secretions, serum, urine, saliva, milk, tears, nasal secretions, fecal material, or perspiration, and the test may therefore be considered a specific test for seminal stains. Of animal semen, only the Rhesus monkey gives a positive reaction with the antiserum, a fact that will rarely complicate any investigation of sexual assault.

The full uses of the p30 protein have not yet been fully realized, but it will definitely aid in the examination of vaginal aspirates in rape cases. Vaginal washes are routinely taken when a rape victim receives initial medical treatment, and these washes are examined for the presence of acid phosphatase. Acid phosphatase is an excellent test for seminal stains, but suffers a serious and frequently fatal defect when applied to vaginal washes. After 6 to 8 hours, the level of prostatic acid phosphatase from the male falls to a level where it is roughly comparable to the level of endogenous vaginal acid phosphatase, and can therefore no longer be used as an indication of sexual assault. Since vaginal secretions are totally devoid of p30 protein, however, the demonstration of this protein in vaginal aspirates may permit an opinion concerning the presence of seminal fluid out to perhaps 30 of 40 hours. Further research concerning this matter is being conducted and the results should be available within a year.

A promising area in the forensic identification of soil involves the use of soil enzymes to characterize a sample of soil as having originated from a particular geographic location.[3] Soil enzymes are present due to the

[3] "Enzymatic Characterization of Soil Evidence, " John I. Thornton and A.D. McLaren, J. For. Sci. 20:674 (1975).

metabolic activity of higher plants, but from the standpoint of the total biomass of the soil, are primarily due to the metabolic activity of bacteria and fungi. Since enzymes are biochemical catalysts and are not consumed in a reaction, it is possible to demonstrate even an infinitesimal amount of an enzyme in a soil sample. The complexion and amount of soil enzyme activity with respect to the enzymes urease, invertase, phosphatase, arylsulfatase, and trypsin will characterize a soil sample not only with respect to a geographical location, but also with respect to a particular time, since the activity is constantly changing. This approach is conceptually valid, but has suffered in the past from a lack of sensitivity. It is likely that in the near future the sensitivity of the enzyme assays will be imporved through the application of radiochemically labeled or flourescent enzyme substrates. At such time as these refinements are made, this approach will certainly assume a more prominent role in the forensic characterization of soil evidences.

It is possible to combine an automatic sampler and a computer to an analytical instrument such as the gas chromatograph or high pressure liquid chromatograph for the purpose of automated drug identification. A system of this sort may also be devised to conduct automated blood alcohol determinations. There is an enormous benefit in having an installation of this nature in a laboratory devoting a large percentage of time to these evidence categories. The system can work with minimal human attention or can even work at night, with the results printed out on a teletypewriter. Although the initial installation is costly and the maintenance is not insignificant, a system of this sort can free personnel for other work and can assist materially in the maintenance of their sanity.

One of the major advances in criminalistics in the past few years has been the use of the scanning electron microscope equipped with an X-ray analyzer to magnify gunshot residues removed from the hands of persons suspected of having fired a weapon. Gunshot residues as visualized with the scanning electron microscope consist of generally spheroidal particles of about five-millionths of a meter or less. The X-ray analyzer may then identify the elements associated with the primer mixture of the ammunition used, restricting the analysis to just the particle imaged by the microscope.

This represents a conceptual and technical leap beyond previous approaches to the question of gun shot residues.[4] The form of the particles makes them readily distinguishable from other debris which may be encountered on the hands of the individual, and the ability to associate an image of the particles with the elements in the primer mixture distinguishes the particles from other environmental sources of lead, barium, and antimony. With this technique, it is possible to determine gunshot residues up to 12 hours after firing.

The laser appears to have several uses in a crime laboratory to extend the capability of the laboratory beyond what it could have achieved without this instrument. A high power laser, something on the order of 5 watts of power from an argon ion laser, may promote a native flourescence in a latent fingerprint. Roland Menzel, currently at Texas Tech University, pioneered this work at the Xerox Research Institute, and has nearly perfected it.[5]

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4 Final Report on Particle Analysis for Gunshot Residue Detection, G.M. Wolten, R.S. Nesbitt, A.R. Calloway, G.L. Loper, and P.F. Jones, The Aerospace Corporation, El Segundo, Ca., Report No. ATR-77(7915)-3, Law Enforcement Assistance Administration, U.S. Dept. of Justice, Washington, D.C., 20024.

5 Fingerprint Detection with Lasers, E. Roland Menzel, Dekker, New York, 1980.

With the use of the laser it is possible to develop latent fingerprints on a variety of surfaces that ordinarily cause problems. These surfaces include certain types of plastics such as styrofoam, black electrician's tape, and even human skin.

One of the more promising aspects of Menzel's work is his observation that the wavelength of the flourescence stimulated by the laser changes with the age of the fingerprint. This raises the possibility of using laser flourescence to determine the age of a latent fingerprint. Dr. Menzel points out that the basic necessities to study this spectral change with age, namely the ability to measure the spectra and to isolate the flourescing compounds in the fingerprint material, are in fact accessible. Research in this area is indeed warranted, since at the present time there is no method available to determine the age of a latent fingerprint.

In working with the laser detection of fingerprints, the Forensic Science Group at the University of California at Berkely discovered quite unintentionally that the high enerty beam from the argon ion laser could propagate interference figures upon reflection from the surface of a piece of glass.[6] The interference figures, or Fizeau fringes as they are called by physicists, thus produced constitute a sort of microtopographical map of the surface of the glass. The continuity of the meandering lines of the interference figures may establish that two fragments of glass had at one time been joined. The technique holds promise for the reconstruction of fractured glass, and represents the only technique at present by which a reconstruction can be achieved with glass that has been cut with a glass cutter.

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6 "Reconstruction of Fractured Glass by Laser Beam Interferometry," John I. Thornton and Paul J. Cashman, J. For. Sci. 24:101 (1979).

CRITICAL ISSUES

There are a number of factors which place constraints on the quality and effectiveness of the criminalistic function, quite apart from the technical limitations discussed previously. For a more extended discussion of these matters, the reader is referred to the text by Fox and Wynbrandt.[7]

Several of these factors (e.g. budgetary constraints) represent a fact of life for virtually all governmental operations and are certainly not unique to the criminalistics enterprise. Other less intractable factors may be resolved with a reasonable amount of effort; others will require an attentiveness which has frequently been absent in the nation's crime laboratories, and will not be resolved until such time as the component segments of the criminal justice system act in concert to resolve their conflicts.[8]

One factor which detracts from the ability of a criminalistics laboratory to fulfill its fundamental mission is a lack of awareness and understanding of the criminalistics enterprise on the part of law enforcement

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7 Crime Laboratory Management Forum - 1976, R.H. Fox and F.H. Wynbrandt (eds.), The Forensic Science Foundation Press, Rockville, 1976.

8 The author is not trying to be in any way snide in referring to "conflicts" among the various segments of the criminal justice system. It is not personal conflicts that are at issue, but philosophical, organizational, operational, and budgetary conflicts. Conflicts (in the polite sense of the word) such as these are legion. The fact that the various segments must ultimately compete for resources from the same fiscal niche is probably sufficient justification alone for a difference in how many things are perceived by the different elements.

executives, attorneys, and the judiciary. There is a distinct trend away from this attitude, but in the past there has frequently been a tendency on the part of police administrators to view a crime laboratory as a public relations gimmick rather than as a serious investigative tool. Many crime laboratories owe their existence not to an enlightened attitude on the part of a progressive police executive, but rather to a scandal involving mismanaged physcial evidence which shamed the police department into the installation of a laboratory.

Attorneys may also misperceive the true criminalistic ethis. They frequently view the criminalistic function in terms which are strictly utilitarian, striving to use physical evidence in an advocacy sense and with little regard for the efforts of the criminalist to maintain an atmosphere in the laboratory which is objective and conducive to the proper exercise of professional considerations. This is seen most acutely in the younger attorney who, after passing the bar, joins the staff of the public prosecutor or the public defender in order to obtain trial experience. Since it is the attorney who will ultimately orchestrate the presentation of the physical evidence in court and bears the responsibility for the conduct of the case in general, it is not suprising that the attorney may wish to shape and form the evidence to put forth the best case possible. The danger here, however, is that the criminalist is placed in the position of attempting to describe the evidence as he or she would like it to be. The role of the attorney as an advocate is a valid one and necessary to our system of justice. But law and science are not synonymous. They have arisen in response

to rather different needs and view proof in a somewhat different manner.[9] The goals set for the criminalistics discipline by attorneys and the judiciary are not in all regards the same goals as those set by the practitioners themselves. The goal of science has been traditionally cast as searching for "truth" while the goal of law has been the just resolution of human conflict. Science takes for its ultimate judgment one criterion alone. It must be truthful.

A somewhat different phenomenon occurs with respect to the judiciary. When an attorney is appointed to the bench, he or she sheds, of course, the mantle of advocacy, but in doing so frequently severs all ties to other operation aspects of the criminal justice system. Judges tend to eat their lunches alone. This may be necessary to ensure judicial detachment, but thwarts communication. The result of this is that judges see only those aspects of criminalistics that are presented in their own courtrooms. Arguments are made not only about what things mean, but also about what things are. All manner of mischief abounds, with phony issues and scientific strawmen set up and knocked down. If this occurs, there is a tendency on the part of the judiciary to misperceive the true criminalistics function.

A second factor which thwarts the effectiveness of the criminalistics function is ineffective coordination between the evidence recovery process and the evidence analysis process. It is generally accepted that no more than about 3 percent of the physical evidence potentially available for examination is ever graced by any type of laboratory examination. Physical

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9 ". . . the rule conferring upon an accused the right not to be questioned may be a good or a bad rule, [but it] has not been made better or worse by the invention of printing or the aeroplane." The Proof of Guilt, Glanville Williams, Stevens, London, 1958, p. 122.

evidence may be examined in an investigative or a prosecutorial sense. In the investigative sense, the identity of a suspect has not yet been unequivocally established, and the results of the physical evidence examination may narrow the field and eventually lead to the most likely suspect. In the prosecutorial sense, the identity of the suspect has been established and the physical evidence examination is being used to prepare for trial. If there is less than optimum communication between the laboratory and other agencies, which is frequently the case, then several aberrances are possible. At the investigative level, the evidence may not be submitted to the laboratory at all (about 97 percent) or it may be submitted too late to be of any meaningful value in steering the investigation. Alternatively, the evidence may be submitted to the laboratory in cases where the evidence, when examined, will not make any identifiable difference to the disposition of the case. Any of these situations represent a potential insult to the value of the laboratory to provide effective service.

At the prosecutorial level, a laboratory may not conduct a systematic analysis of all aspects of the physical evidence, but only those analyses that are requested by the prosecutor and which comport with the prosecutor's view of the case and of the issues that may be raised at the trial. This may result in a number of things left undone on the eve of trial. They may remain undone, or they may be performed hurriedly. Either situation leads to inefficient service.

A third factor which limits the effectiveness of the criminalistics enterprise is an inability on the part of the criminalistics discipline to articulate and communicate its needs and concerns to the appropriate elements of the criminal justice system. This reflects in part the historical attachment of operational crime laboratories to the police function. Police

executives have not always been receptive to the pleas of the laboratory for support. When deciding between an infrared spectrophotometer and a new police cruiser for the same price, a police executive, having come up through the ranks and being more closely aligned with the traditional police function, may decide in favor of the item with which he is most familiar. but problems exist in communicating the needs and concerns of the laboratory to other segments of the criminal justice system as well. Frequently there is no real forum outside of the courtroom for the confluence of science and the law, and the courtroom is no place to set laboratory policy.

Another factor undermining the effectiveness of the crime laboratory is burdensome caseloads. In many instances laboratory resources are largely devoted to non-index crimes such as blood alcohol analysis, marijuana identification, and routine drug cases. The capabilities of the laboratory become so saturated with these types of cases the the laboratory becomes less and less capable of providing optimum service in connection with burglary, assault, and other felony cases. There is a real danger that the skill inventories of the criminalist will diminish through lack of use. A similar situation has been described in connection with clinical laboratories; hospital laboratory personnel that spend virtually all of their time determining the specific gravity of urine samples or conducing hematocrit determinations lose their ability to identify the protozoan in the blood responsible for malaria. In the same fashion, a criminalist who spends most of his or her time conducing routine drug determinations becomes a drug chemist, with a commensurate atrophy of the ability of conduct sophisticated examinations in many other trace evidence categories.

Although certainly not a factor unique to crime laboratories, budgetary

restrictions may prevent the development of increased laboratory capabilities, or, more insidiously, may thwart the maintenance of existing capabilities. The nation's crime laboratories are notoriously understaffed and undercapitalized. As virtually all governmental functions have moved from a growth phase through a steady-state phase and now into a position of decline, crime laboratories are now competing for funds with other services which are equally essential and equally virtuous.

Another contributing factor would appear to be questionable management practices on the part of some laboratory directors. Laboratory directors are either police officers with little or no scientific training, a situation which most assuredly does not promote efficiency in the administration of a laboratory, or are older criminalists whose training has been technical rather than managerial. In some instances the directors of laboratories have exercised little control over the amount, type, and quality of evidence submitted for laboratory examination, or have been insensitive to intra-laboratory matters which are of vital concern to laboratory personnel.

A certain measure of the respect of other segments of the criminal justice system and of scientists outside of the criminalistics profession will always be denied unless there is a clear demonstration of competency on the part of the laboratory. Competency takes on a number of forms, one of which is the institutionalization within the laboratory of an adequate quality control program. There is no real consensus within the criminalistics community as to what constitutes an adequate quality control program, but there is an ever increasing tendency to incorporate proficiency testing into any program. This invariably involves some aspect of blind testing, where the laboratory personnel conduct whatever tests are indicated and the correct

results are not divulged until after the completion of the tests and the formulation of an opinion. Any laboratory operation which does not engage in some activity of this sort is likely to be crippled in its effort to claim technical competency.

One final factor which has had a constraining influence on the status of criminalistics in the United States, and which is also related to quality assurance, is the sobering problem of staffing a laboratory with trained personnel. Training programs in criminalistics exist in pathetically few institutions of higher education, and the graduates of these programs are too few to meet the needs of the profession. Failing in the effort to attract personnel with fundamental training in the criminalistics profession, many laboratories have been forced to accept scientists from other scientific disciplines. This may be entirely satisfactory, but places a great premium upon the adequacy of the basic scientific training of these individuals. A good scientist can make himself into a good forensic scientist, but not every recipient of a baccalaureate degree of one of the natural or physical sciences is necessarily a good scientist. Certainly if our own lives were at stake, we would want the evidence examined by someone better than just the "class-average." There is a possibility here that laboratory personnel with no preprofessional training may endanger the credibility of the laboratory operation. On-the-job-training is an important aspect of the professional development of any newly hired personnel, but cannot be carried out nonchalantly.

Any in-service training program must be coordinated, comprehensive, and must have an unswerving adherence to the fundamental "quality ethic" of the profession. Inadequate training, or inattentiveness on the part of a supervisor at any point in the training of new personnel, will ultimately lead to disaster. Mortal damage can be done in minutes to the reputation of a laboratory which was developed through years of painstaking attention to detail.

These factors have special implications for specific segments of the criminal justice system. All segments have in common the responsibility of demanding rigorous technical competency on the part of the laboratory staff at all stages of the evidence examination process. No disservice is done to a laboratory by placing the laboratory on notice that there is no expectation of anything other than quality work. It is, after all, the wolf that keeps the caribou herd strong by culling out the lame and the halt. It is entirely appropriate that opposing attorneys, judges, and critical police administrators do something of the same.

Police executives should recognize that the criminalistic function is within the penumbra of traditional police operations, and that the psychological antecedents of skilled laboratory personnel are different from those of most police officers. The significance of this is that a laboratory cannot be administered in the same fashion as other aspects of a police agency. This is not to say that a laboratory should be viewed as an aggregation of primadonnas, but rather that the aspirations and factors motivating the laboratory staff are likely to be different from those of most police officers. A recognition of this difference is more likely to ensure the harmony within the organization necessary to the proper development of criminalistics.

Attorneys should recognize that the criminalist can be an advocate of his or her professional opinion, but can never be an advocate of the guilt or innocence of the accused.

The judiciary should recognize that there are some fundamental differences at the interface of law and science. If these conflicts are invariably resolved in favor of the law, it makes the criminalist less of a scientist, and removes some of the justification for the criminalist being in the courtroom in the first place.

LEGAL CITATIONS

Alcohol Analysis of Blood, Breath and Urine

Arizona v. Superior Court
487 P.2d 511

California v. Hitch
527 P.2d 361

California v. Foulger
103 Cal. Rptr. 156

California v. Miller
125 Ca. Rptr. 341

Edwards v. Oklahoma
544 P.2d 60; 429 F. Supp. 668; 577 F.2d 1119

Florida v. Mitchell
245 So. 2d 618

Garcia v. District Court
589 P.2d 924

Minnesota v. Oevering
268 NW2d 68

Missouri v. Hamaker
524 SW2d 176

Missouri v. Hanrahan
523 SW2d 619

New Hampshire v. Shutt
363 A.2d 406

New Jersey v. Bryan
336 A.2d 511

New Jersey v. Burns
388 A.2d 987

New Jersey v. McGeary
322 A.2d 830

Oregon v. Sutton
450 P.2d 748

Ross v. State of Oklahoma
556 P.2d 638

Scales v. Mesa City Court
594 P.2d 97

Schmerber v. California
384 U.S. 757; 86 S.Ct. 1826

Smith v. Mott
100 So.2d 618

South Dakota v. Heimer
278 NW2d 808

Turnage v. State Dept. of Transportation
282 So.2d 68

Washington v. Canady
585 P.2d 1185

Blood Evidence

Cady v. Dombrowski
413 U.S. 433

California v. Lindsey
149 Cal. Rptr. 47

Connecticut v. Walters
138 A.2d 786

Kansas v. Washington
29 Cr. L. Reporter 2450

Maine v. Rolls
389 A.2d 824

Michigan v. Horton
28 Cr. L. Reporter 2236

People of Michigan v. Tobey
231 NW2d 403

Rhode Island v. Souza
29 Cr. L. Reporter 2015

Shanks v. Maryland
45 A.2d 85

State v. Bass
105 SE2d 645

State v. Speller
53 SE2d 294

State of Washington v. Bauman
468 P.2d 684

U.S. v. Kearney
420 F.2d 170

U.S. v. Smith
470 F.2d 377

Williams v. Florida
197 So. 562

Drug and Narcotic Analysis

Coppolino v. Florida
223 So.2d 68

Dixon v. Indiana
357 NE2d 908

Hand v. State
179 SW 1155

Illinois v. Bertram
358 NE2d 1357

Keith v. Tennessee
542 SW2d 839

Maine v. Philpot
365 A.2d 122

People v. Williams
331 P.2d 251

State v. Baca
472 P.2d 651

State v. Carvelle
290 A.2d 190

State v. Smith
244 So.2d 824

Fiber Evidence

Bester v. Mississippi
77 So.2d 270

California v. Smith
298 P.2d 540

California v. Trujillo
194 P.2d 681

Hunter v. Texas
468 SW2d 96

Illinois v. Kirkwood
160 NE2d 766; Cert. Den. 363 U.S. 847

Kansas v. McClain
533 P.2d 1277

Massachusetts v. Bartolini
13 NE2d 382; Cert. Den. 304 U.S. 565

Michigan v. Tobey
231 NW2d 403

North Carolina v. Woods
213 SE2d 214

Nicholas v. Texas
270 SW 555

State v. Ray
164 SE2d 457

Washington v. Jones
572 P.2d 71

Fingerprint and Palmprint Evidence

Anderson v. Florida
241 So.2d 390

Arizona v. Carter
578 P.2d 991

Harvey v. Colorado
495 P.2d 204

Hawaii v. Murphy
575 P.2d 448

Illinois v. Van Zandt
405 Ne2d 881

Illinois v. Ware
402 NE2d 762

Jones v. Maryland
218 A.2d 7

Lester v. Oklahoma
416 P.2d 52

Missouri v. Thompson
610 Sw2d 629

New Jersey v. Hofford
404 A.2d 1231

North Carolina v. Abernathy
244 SE2d 373

North Carolina v. Banks
245 SE2d 743

Ohio v. Nebonzny
244 NE2d 784

U.S. v. Beasley
435 F.2d 1279

U.S. v. Gray
464 F.3d 632

Xanthull v. Texas
403 SW2d 807

Firearms Identification

Bruce v. Indiana
375 NE2d 1042

Day v. Oklahoma
518 P.2d 1283

Hancock v. Florida
105 So. 401

Illinois v. Lyons
358 NE2d 1183

McLendon v. Florida
108 So. 406

Massachusetts v. Ellis
364 NE2d 808

Ohio v. Bates
358 NE2d 584

Pennsylvania v. Coccioletti
425 A.2d 387

Pickens v. Oklahoma
450 P.2d 837

Riner v. Florida
176 So. 38

Rowe v. Florida
163 So. 22

Sheffield v. Alabama
392 So.2d 1233

Glass Evidence

Colorado v. Moreno
400 P.2d 899

Rolls v. Alabama
46 So.2d 8

Wheller v. Indiana
264 NE2d 600

Wisconsin v. Spring
179 NW2d 841

Gunshot Residues

Chatom v. Alabama
348 So.2d 828

Nebraska v. Journey
271 NW2d 320

Pennsylvania v. Sero
387 A.2d 63

State v. Ross
523 SW2d 841

U.S. v. Stifel
433 F.2d 431; Cert. Den. 401 U.S. 994

Hair Evidence

Cloud v. Virginia
232 SE2d 790

Fultz v. Indiana
358 NE2d 123

Goddard v. Florida
196 So. 596

Illinois v. Garza
415 NE2d 1328

Illinois v. Kirkwood
160 NE2d 766; Cert. Den 363 U.S. 847

Larmon v. Florida
88 So. 471

North Carolina v. Ray
164 Se2d 457

Oregon v. Harris
405 P.2d 492

Padilla v. Colorado
397 P.2d 741

Parks v. Georgia
46 SE2d 504; 58 SE2d 142

Skinner v. Virginia
183 SE2d 725

State v. Andrews
134 A.2d 425

State v. Barber
179 SE2d 404

State v. Bauman
468 P.2d 684

State v. Pearson
210 SE2d 887

Paint Evidence

Cardwell v. Lewis
417 U.S. 583

Kansas v. Hansen
427 P.2d 627

Kansas v. Wasinger
556 P.2d 189

Pearson v. U.S.
192 F.2d 681

State v. Vaccaro
298 A.2d 788

U.S. v. Longfellow
406 F.2d 415; Cert. Den. 394 U.S. 998

Physical Match Evidence (Tear or Fracture Match)

Cordes v. Texas
112 SW 943

Hunter v. Texas
468 SW2d 96

Illinois v. Wallage
186 NE 540

Padilla v. Colorado
397 P2d 741

Tomolillo v. Maryland
245 A.2d 94

Saliva Evidence

N Y. v. Trocchio
N.Y.S. 2d 639

Seminal Fluid

Edwards v. Texas
344 SW2d 687

Illinois v. Kirkwood
160 NE2d 766; Cert. Den. 363 U.S. 847

Jensen v. Wisconsin
153 NW2d 566

Maxwell v. Arkansas
370 SW2d 113

Michigan v. Horton
28 Cr. L. Reporter 2236

Michigan v. Lovett
272 NW2d 126

Missouri v. Moore
435 SW2d 8

New Mexico v. Till
450 P.2d 753

Wall v. Texas
417 SW2d 59

Serial Number Restoration

Illinois v. Snow
316 NE2d 216

Shoeprint and Tiretrack Evidence

California v. Daniels
172 Cal. Rptr. 353

Cardwell v. Lewis
417 U.S. 583

Connecticut v. Smith
242 A.2d 763

Ferguson v. Florida
28 So.2d 427

Flowers v. Texas
415 SW2d 178

Illinois v. Lomas
416 NE2d 408

Illinois v. Robbins
315 NE2d 198

Johnson v. Indiana
380 NE2d 566

Lee v. Florida
67 So. 883

North Carolina v. Silhan
275 SE2d 450

Payne v. Oklahoma
239 P.2d 801

Pennsylvania v. Mangini
386 A.2d 482

Rodriquez v. Florida
398 SW2d 123

U.S. v. Henley
374 F.2d 341; Cert. Den. 388 U.S. 923

Soil and Mineral Evidence

Aaron v. Alabama
122 So.2d 360; 155 So.2d 334

Arizona v. Guerrero
120 P.2d 798

California v. Smith
298 P.2d 540

Holmes v. Arkansas
520 SW2d 715

Missouri v. Washington
335 SW2d 23

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221 A.2d 199; Cert. Den. 385 U.S. 980

Oklahoma v. Riggle
585 P.2d 1382

State v. Atkinson
167 SE2d 241

State v. Coolidge
260 A.2d 547; 403 U.S. 443

Toolmark Identification

Connecticut v. Smith
242 A.2d 763

Holley v. State
179 So.2d 577

Illinois v. French
375 NE2d 502

Iowa v. Knudtson
195 NW2d 698

State v. Montgomery
175 Kansas 176

GLOSSARY

ABO system	A blood group system in which the genetic markers are on the red blood cells.
Absorptiometry	The measurement of the ability of a substance in solution to absorb light; applicable to spectrophotometry.
Absorption-elution	A test used for the typing of dried blood-stains, principally in connection with the ABO system.
Absorption-inhibition	A test used for the typing of dried blood-stains, now largely obsolete.
Accelerant	A flammable liquid used to ignite and spread a purposefully set fire.
Acid phosphatase	An enzyme; prostatic acid phosphatase is a test for seminal fluid, erythrocyte acid phosphatase is a genetic marker on the red blood cell differing from the acid phosphatase in seminal fluid and in vaginal secretions.
Adsorption	The affinity of one material to collect on the surface of another through molecular interaction; relevant to chromatography and certain aspects of serology.

ADA type	Adenosine deaminase, a genetic marker found in red blood cells.
Agglutination	The clumping of red blood cells, used as an indicator of an antigen-antibody reaction.
- agglutinin	Antibody causing agglutination.
- agglutinogen	Antigen stimulating agglutinin production.
AK type	Adenylate kinase, a genetic marker found in red blood cells.
Amino acid	The building blocks from which proteins are made; reacts with ninhydrin in the development of latent fingerprints.
Antibody	A protein in serum that reacts specifically with a complementary antigen to cause agglutination, precipitation, or other types of binding.
Antigen	A protein or protein/polysaccharide complex in serum or attached to the red blood cell that determines a genetic marker by specific reaction with antibodies.
Arch	The third most frequently encountered fingerprint pattern, characterized by ridges entering the print from one side and exiting on the other.
Caliber	The diameter of a bullet. (N.B., caliber is not to be taken literally in every instance; the diameter of a .38 Special is actually .357 inches).

Chromatography	An isolation technique whereby mixtures of materials are separated by means of the attraction of a material to a stationary phase while being propelled by a mobile phase; primarily a separation technique, but also an identification technique.
Class characteristics	Characteristics of an item which permit the item to be placed in a general category but which would not distinguish the item from other similar items.
Confirmatory test	A test following a presumptive or screening test, the purpose of which is to unequivocally establish the nature of a material.
Density	A weight per volume ratio, and one of the more fundamental physical properties of any homogeneous material.
Dispersion	The variation of refractive index with wavelength; relevant to the comparison of glass evidence.
EAP	Erythrocyte acid phosphatase, a genetic marker found in red blood cells.
Electrophoresis	A separation and identification technique which involves the mobility of a material in a charged electrical field.

Enzyme	A biochemical catalyst; polymorphic enzymes exist in more than one form and are under genetic control.
Erythrocyte	Red blood cell.
EsD	Esterase D, a polymorphic enzyme found in red blood cells.
Exemplar	A known specimen, used for purposes of comparison with an evidence specimen.
Flourescence	The emission of one form of radiant energy upon the absorption of another form; in a forensic context, flourescence frequently involves the emission of visible light following exposure to ultraviolet energy.
Friction ridges	Also called papillary ridges or dermal ridges, the raised structures that form patterns on the tips of the fingers, on the palms, and on the soles of the feet.
Gauge	A measurement of the bore of a shotgun; equivalent in concept to caliber, but expressed differently.
Genotype	The total genetic characteristics inherited from one's parents.
GLO I	Glyoxalase I, a polymorphic enzyme found in red blood cells, in semen, and in vaginal secretions.

Gradient	A tube filled from bottom to top with successively lighter liquids to establish a density continuum; used primarily for the characterization of soil and mineral evidence.
Gunshot residue	Materials found on the hands of a person who has fired or handled a weapon, originating from the propellant or the primer mixture.
Hp	A serum protein under genetic control, for which three phenotypes exist.
Identification	The process of placing an item into a unit category; frequently used in the same sense as the more restricted term "individualization."
Individual characteristics	Characteristics which serve to distinguish an item uniquely from all other items of a similar type.
- individualization	The process of establishing an item as a unique entity, distinguishable from all other items of a similar nature or type.
Isoenzyme type	The phenotype determined by enzymes in the blood which are under genetic control.
Lattes test	A test for blood group antibodies, generally run in conjunction with tests for blood group antigens.

Latent fingerprint	A fingerprint resulting from the deposition of perspiration or oils; frequently invisible prior to development, from the Latin word meaning "hidden."
Loop	The most frequently encountered fingerprint pattern, characterized by ridges entering from one side of the print, rising in the center, curving around and exiting on the same side of the print; radial loops enter and exit on the side of the print facing the thumb, while ulnar loops enter and exit on the side facing the little finger.
Neutron activation analysis	The identification of in organic elements by measuring the characteristic radiation emitted after the material has been bombarded with high-energy neutrons.
Ninhydrin	The principal method of development of latent fingerprints on porous surfaces such as paper; reacts with amino acids in perspiration.
p30	A semen specific protein which permits the immunological identification of seminal stains.
Phenotype	The genetic traits actually displayed by an individual.

Physical evidence	Any tangible material that associates a crime with a suspect or establishes an element of the crime.
Precipitin test	A test for species origin of blood.
Presumptive test	A screening test, used to establish the general nature of a material in order to select subsequent tests of a more definitive type.
Pyrolysis	The heating of solid materials in an inert atmosphere to form simpler compounds; generally used in conjuction with gas chromatography.
Reagent	A chemical used to identify other substances by virtue of its characteristic reactivity.
Rh system	A blood group system of the red blood cell.
Refractive Index	The ratio of the speed of light in a vacuum to the speed of light in any translucent material; a fundamental optical property of a material by means of which a number of different types of physical evidence may be identified or compared.
Rhodizonate test	A sensitive test for lead and antimony in gunshot residues.
Screening test	Presumptive test
Serum	The liquid portion of the blood after the cells and other formed elements have been removed.

Serum protein type	The phenotype determined by serum proteins in blood that are under genetic control.
Serology	The aspect of immunochemistry dealing with blood and other body fluids.
Spectrograph	An analytical approach to the identification of inorganic elements by means of their characteristic emission of energy upon excitation.
Spectrophotometer	An analytic approach to the identification of organic compounds by means of their absorption of radiant enerty in a characteristic and selective fashion.
Spermatozoa	The cellular component of seminal fluid.
TMDT	Trace metal detection test; a test to determine if a person has handled a weapon by demonstrating traces of iron.
Trace elements	Inorganic elements in a material of an adventitious nature, the determination of which may characterize a material as having originated from a particular source.
Whorl	The second most frequently encountered fingerprint pattern, characterized by circular or generally rounded ridges and two deltas.

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FORENSIC ODONTOLOGY

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EXECUTIVE SUMMARY

Definition

Forensic Odontology is the branch of dentistry that deals with the examination of dental evidence and with its evaluation and presentation with regard to legal proceedings. The expertise of the forensic odontologist is most frequently used in three major areas:

- Identification -- the comparison of any type of dental evidence of "unknown" evidence with "known" examplars of similar evidence.
- Trauma -- the examination, documentation and evaluation of injuries to the teeth, face, jaws and other oral structures.
- Bite Marks -- the examination, documentation and comparisons of the patterned injuries on skin or other substances caused by the human dentition.

The variety of cases in which dental evidence can be of use to the investigator is almost limitless. It can range from the simplest example of dental evidence where mere recognition of evidence of a tooth at a crime scene can lead to the perpetrator to the sophisticated comparisons associated with bite marks. The critical factor in any case is the investigator's abilities to recognize and collect the evidence and then refer that evidence for proper evaluation.

Identification is the most common use of dentistry in the Justice System. It is useful in the identification of burned, fragmented, mutilated, decayed, or otherwise unidentifiable human remains. Dental identification techniques are most frequently associated with the identification of the dead. However, the same techniques have been valuable tools in establaishing the identity of

unconcious living persons who are not visually recognizable. By comparing current charting of the individual's dentition with prior dental charts of known individuals, identity can often be established.

Identification

Forensic Odontology is not new in the United States. The first recorded case of a dentist making an identification occurred during Revolutionary War times. Paul Revere, along with his other talents, was a dentist. A patient of his, General Joseph Warren, was killed in the Battle of Bunker Hill and buried in an unmarked grave. The body was subsequently recovered and a prothesis was identified by Revere as that which was made by him for General Warren.

The first case at bar involving the use of dental identification occurred in Massachussets over one hundred and thrity years ago; The Webster-Parkmen Case.

Dr. Webster, Professor of Chemistry at the Harvard Medical School, was convicted of murdering Dr. Parkman, a physician and Harvard Medical School graduate. Remains of a body were found in Webster's office and fragments of porcelein denture and skull were found in a furnace in Webster's laboratory.

Parkman's dentist identified the fragments as that of his patient after comparison with a dental model of his patient. He further rendered an opinion that the porcelein dentures had to have been in the skull of the victim when placed in the furnace or they would have been destroyed. Depending upon the evidence that is available, identifications similar to Warren and Parkman could be valid today.

Trauma

Examinations of injuries to the hard and soft structures of the oral cavity are valuable in both criminal and civil cases. The questions related to this type of examination usually involve causation.

Bite Marks

Each person has teeth which are unique and individual to that particular person because of many factors such as the morphology of each tooth, tipping, rotations, spacing and arrangement, missing teeth, wear pattern, dental restorations, breakage, and the like.

A very simplistic concept of a bite mark is that of the mark of a tool with many unique and individual characteristics. The mark could be in any substance. However, in the criminal justice field, bite mark evidence usually occurs as human bites in skin of the perpetrators or victims of certain catagories of crime.

The application of forensic odontology can often yield answers to many more varied and often subtle aspects of a case. Evaluation of injuries to the hard and soft structures of the oral cavity are frequently important to support or to impeach the statements of alleged victims and perpetrators.

CURRENT CAPABILITIES AND LIMITATIONS

The forensic odontologist should possess a professional dental degree, a D.D.S. or D.M.D. and have completed a formal course in forensic odontology, as a minimum. Certification in forensic odontology requires the individual to submit extensive credentials and documentation of forensic case work before being permitted to take the qualifying examination for certification as a diplomate of the American Board of Forensic Odontology. Certification helps to assure the proficiency and competence of those practicing in the specialized field of forensic odontology.

Forensic odontology involves applying principles of dentistry and science to answer questions pecular to legal investigations. However, conclusive answers can not always be provided. As an example, in bite mark cases available technology and knowledge limit the ability of the forensic odontologist to "positively" conclude that an individual, definitely made a bite mark.

The forensic odontologist is most often called into a case to examine evidence collected by someone else, usually the police investigator. Unfortunately, very often the importance of the dental evidence is realized after the initial scene or body investigation. Thus, the odontologist often has less than ideal evidence or photographs with which to work. This is most frequently encountered in bite mark cases. But also applies to identification cases.

Most forensic odontologists devote a relatively small percentage of their time to actual forensic work. Most are engaged in dental practice or teaching. Very often, the odontologist serves as a consultant to law enforcement

and medical examiner agencies.

Identification

The most common use of dentistry in the justice system is in the identification of decomposed, burned, fragmented, mutilated, or otherwise unidentifiable human remains. The teeth are the most durable of the tissues of the body and dental restorations such as metal crowns, porcelain jackets, inlays, or prosthetic appliances resist heat in the range of 2000 F°.

The combinations of teeth missing or present, surfaces filled or unfilled, filling materials, prosthetic appliances, anomalies and the like are almost limitless. X-ray films, study casts, and certain photographs all contain numerous graphic areas.

Dental identification basically is a comparison of some type of dental evidence from the unknown person with similar dental evidence obtained from a known record of the person in question. The quality of the examination and comparison in large part, is dependent on the expertise and training of the examiner.

The type of dental record available is a factor in the validity of the result. Dental records may consist of any or all of the following:

1. Written dental records:
    a. Hand written record of cavities
    b. Hand written record of existing fillings
    c. Hand written record of present and missing teeth
    d. Hand written record of treatments
    e. Hand written record of anamolies and/or unusual conditions
    f. Hand written description of prosthetic appliances, tooth shades, etc. (Laboratory Prescription)
    g. Schematic drawings or combinations of items a-f

    h. Machine Printouts (Insurance Payment Record)
2. X-Ray Films
    a. Panoramic (teeth and jaws) of entire mouth
    b. Periapical (segment teeth and roots, jaw)
    c. Bite Wing (segment crowns both jaws)
    d. Lateral Jaw (one side teeth and jaws)
    e. Lateral Skull (teeth jaws both sides)
    f. Anterior-Posterior Skull (anterior teeth)
3. Dental Models
    a. Study Casts (models used in diagnosis)
    b. Prosthetic Models (modles used to fabricate Orthodontic Models dental appliances)
    c. Dies (models of individual teeth)
4. Prosthetic Appliances
    a. Full Dentures
    b. Fixed Partial Dentures (bridges)
    c. Removable Partial Dentures
    d. Crowns and Jackets (caps)
5. Photographs

The most valid type of dental record to use for identification purposes is one in which all the unique and individual characteristics to be used in the comparison are graphically displayed. A check should be made to determine if this record has been tampered with or altered. Any attempt at alteration will be obvious to the trained observer.

X-ray films represent the best record for identification purposes. In fact, the greatest technological innovation in the field of dental identification is the availability and use of dental x-rays for comparisons and identifications. A single dental x-ray film will contain considerable amounts of objective information.

Dental models are also an excellent source for comparisons. In both x-ray films and dental models, numerous morphological characteristics delineating dental treatment and restorations are present.

It is critically important in all cases where dental evidence and records are to be used for identification purposes, that the validity of the "known" evidence is ascertained.

The problem of subjectivity versus objectivity can arise in identification cases. Even though this area of forensic odontology rarely sees opposing expert opinion as to the validity of an identification. The seeming lack of controversy is worthy of note since no published standards exist describing what points of comparison must exist before a valid identification can be made.

Using an x-ray film as an example, generally accepted dental terminology is used to describe the various things which can be interpreted by the examiner. This is done for both the films which are being compared. Differences in the films, perhaps due to aging, subsequent dental restorations, tooth extraction, etc. must be reconciled in the mind of the examiner and an opinion formed as to whether these two films were taken, at different times, but on the same person. The examiner is making a judgement based upon his training and experience in the field.

Written dental records present a totally different set of circumstances regarding their value as a tool to make an identification. The less sophisticated examiner might be much more willing to make an identification based upon a listing of dental restorations placed in teeth. The forensic odontologist realizes that there is considerable more information in a single dental x-ray film than in a record of fillings placed. However, a written record in conjunction with other information could still be extremely valuable.

TRAUMA

Examinations of injuries to the hard and soft structures of the oral cavity are valuable in both criminal and civil cases. The questions related to this type of examination usually involve causation.

In order to make valid judgements, the following types of evidence are valuable:

1. Hospital Records*
2. Dental Treatment Records*
3. Photographs

Medical personnel will sometimes photograph unusual injuries. However, most pictures available in these cases are police photographs taken because of the allegation of a criminal act. As such, they may not be very useful to the forensic odontologist.

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* Included in these will often be narrative descriptions of injuries and treatment rendered, x-rays films, professional opinions of injury age, statements to doctors or paraprofessional personnel (by the patient or by others) which allege the manner in which the injury was caused.

A young woman alleged that she had received multiple kicks and punches to the mouth and face during an attempted sexual assault. Upon examination it was found that a porcelain jacket (cap) and crown of the two central incisors were missing from the victim's mouth. The alleged assailant claimed that the loss of the "cap" and fracture of the crown occurred while he was attempting to eject the woman from his apartment and she stumbled and struck those teeth against a wall.

There was no evidence of any injury to the lips, gums, cheeks or face of the woman in police photographs taken after the alleged assault. The dental evidence and the trauma which the woman experienced were consistent with the alleged perpetrator's story and were persuasive in exonerating the alleged assailant.

BITE MARKS

The concept of comparing an injury pattern caused by human teeth on the skin of a crime victim with the teeth of a possible perpetrator is not new. In the past fifteen years vast strides have been made in the field of bite mark techniques. The level of expertise of those examing bite mark evidence has increased measurably because of the recognition, documentation, examination, and reporting of a considerable number of bite mark cases.

The textbook which is widely considered to be the "classic" in Forensic Odontology was published in 1966 by Professor Gosta Gustafson of Sweden. It

is interesting to contrast his chapter on bite marks (which were quite valid in 1966) with the realities of 1983.

> "Because of the relative rarity of bite marks few authorities have examined more than a handful of cases. So little of the experience has been gained which is essential in the evaluation of bite marks."

Today, bite mark evidence in the United States is not all that uncommon. It is found in a significant number of assault cases chich includes sexual activity and in child assaults.

Professor Gustafson goes on to say:

> "It has been said that there is no mouth which is identical to another. Even if this statement is true, bite marks may appear exactly alike, because the great variability in tooth character is not evident in an impression of the bite."

Assuming the above statement refers to bite marks in skin, the examination and documentation of actual case material in which perpetrators of bites have admitted causing the bite marks has shown that statement to be incorrect. The examination of actual case material has shown that skin is quite capable of capturing and reproducing (with excellent fidelity) unique and individual characteristics found in human teeth. These characteristics can be shown to have been reproduced in multiple bites in the skin of the same person and in wax samples used to make "exemplar" bite marks for comparisons.

Other early authorities have been concerned about the need for objective criteria.

> "Berg and Shaidt (1954) came to the conclusion that strict criteria must be placed on any similarity, and they demanded therefore that at least four or five adjacent teeth should correspond exactly before a positive identification could be issued. .... Pedersen and Keiser-Nielsen (1961) laid down the same requirements for a positive identification. Sorup in 1924 considered three to four teeth sufficient."

> "...the similarities which are of the greatest importance are certain individual traits of the incisal edge or the facial surface of the tooth, spacing between teeth, and rotation or displacement in relation to the arch. Frykholm (1953) requires such characteristics in the bite... and in the teeth to be able to make a positive identification."

The implication from these writings of earlier workers in bite mark evidence is that the state-of-the-art was not sufficiently advanced to allow them to reach specific findings. They lacked case experience.

In an article published in the FBI Law Enforcement Bulletin of August, 1972 the author of this article wrote:

> "Unfortunately, human tissue is not the ideal material with which to make an impression of teeth. It is soft, yielding, elastic, three dimensional, and totally unreproducible for comparison purposes."

> "Although we may personally feel more strongly, we have chosen terminology to report our findings based upon our status as responsible forensic scientists. Until we can collect enough case material to give us a broad scientific base, we have chosen to say, "That bite mark is/is not consistent with the dentition of the suspect."

In the past fifteen years, forensic odontologists have collected and evaluated an extensive number of bite mark cases.

In many of these actual cases the question of who caused the bite was not at issue: the perpetrator admitted to causing the bite mark. What was at issue was the time frame and circumstances of the bite(s). Considerable knowledge was gained and shared concerning the correlation between types of patterns of injuries in skin and characteristics in teeth. In light of a decade of knowledge today, because of the extensive research over the past 15 years, it is quite reasonable to report (with reasonable scientific certainty) the results of a positive comparison.

An interesting implication as to how today's forensic odontologists feel about the scientific validity of bite mark evidence can be drawn from

Gustafson's statement that in 1963 Strom, "...claimed that positive identification should always be confirmed by two colleagues." In 1973 Luntz & Luntz, in their Handbook for Dental Identification, techniques in forensic dentistry, stated in the chapter on bite marks:

> "Bearing in mind that he may be called upon to substantiate his opinion in legal proceedings, the dentist must proceed cautiously and with the utmost care. In the preparation of court testimony it would probably be prudent for him to consult with knowledgable colleagues for concurrence relative to his conclusion in a case."

Today, qualified forensic odontologists do not, as a rule, advocate the use of multiple confirmations of findings. In actual trials involving bite mark evidence multiple experts have been used but this has been more a function of the attorneys than of the experienced forensic odontologists.

STANDARDS

Just as in identification comparisons, standard dental names of teeth and areas of teeth are used in bite mark cases.

Beyond that set of standards, the reporting of a positive comparison in a bite mark case is dependent on the training and experience of the forensic odontologist conducting the investigation. Accordingly, such comparisons are both objective and subjective.

There is no common, accepted means by which to assign a numerical value to bite mark comparisons, as for instance in fingerprint identification. Yet

positive comparisons are reported "with reasonable scientific/medical/dental certainty"; a term difficult to find defined in a law library but nevertheless used daily in courts throughout the country.

In an adversary system, taking into consideration all cases of bite mark evidence where an opinion has been rendered, there has been little significant disagreement as to terms among qualified experts. An excellent example of this may be seen in Florida vs. Theodore Robert Bundy.

From the testimony given by forensic odontologists at the Admissibility Hearings and Trial it is evident that the prosecution and defense experts understood exactly what each expert was referring to in reports, depositions, and orally in the courtroom. There was no problem with terminology.

Both sets of experts fully agreed that the pattern injury on the buttocks of one of the homicide victims was caused by human teeth; that the injury pattern caused by lower teeth could easily be distinguished from that caused by upper teeth. They also agreed that the area of the pattern most easily interpreted was caused by lower teeth and that the two semi-ovoid patterns caused by lower teeth were caused by the same lower teeth. Both prosecution and defense experts found the same characteristics, all independently of each other. Both sets of experts agreed that the defendant could have caused the bite marks. The prosecution's experts were of the opinion that the defendant did cause the bite mark "with reasonable scientific certainty." In such a situation it is difficult to imagine that a numerical value of identification would have changed anything.

In addition to human bite marks, animal bites have also been important in the resolution of crimes. The documentation and proper evaluation of the

wound patterns caused by large dogs on children (in the absence of witnesses) has proven to be crucial in those cases.

In some cases the puncture type wounds caused by the teeth of the large dogs has been mistaken for stab wounds. In such cases, forensic odontologists obtain models of the jaws of the dogs involved or the actual jaws of the sacrificed animals and compare the characteristics of those jaws and teeth with the characteristics of the patterned injury on the child.

Investigators should also be aware that bitten or partially eaten foodstuffs or objects, such as pencils, found at crime scenes could also be quite valuable for comparison of characteristics, arrangements, and striations.

The following case illustrates the critical role that bite marks may play in a criminal investigation.

> A six week old infant was found dead in its bassinet from head trauma during a party celebrating his christening. There were thirty adults and seven children present at the party which was being held in an apartment in a high rise apartment house. Investigators noted the presence of bite marks on the cheek, side, and back of the infant.
> Examination of the bite marks revealed, from the size, that they had been caused by a child. From the types of teeth present it could be ascertained that the child who caused the injury patterns was between two and six years of age.
> Only one of the seven children matched that description. Dental models of that childs teeth were obtained and comparisons done. A conclusion was reached that the child in question had caused the bite marks. The child subsequently described undressing the infant, biting the infant, and inflicting the head trauma.

TECHNIQUE

Investigators should carefully examine living or dead victims or perpetrators of the following types of crimes for bite mark evidence.

1. Assault Cases (Adults)
   - a. Non-sexual assaults
   - b. Sexual Activity
     - Forcible
     - Voluntary
     - Heterosexual
     - Homosexual
2. Abuse Cases (Children)
   - a. Multiple Injuries
     - Healed
     - Healing
     - New
   - b. Single Incident
     - New Injuries Only
     - Adult Perpetrator
     - Child Perpetrator

Common Locations of Bite Marks:

Heterosexual Cases

Female Victim - Breasts
- Thighs
- Anterior Shoulder
- Pubic Area
- Neck
- Arm
- Buttocks

CONTINUED

1 OF 5

Cheek

Male Victim - Abdomen

Chest

Arm

Genitalia

Homosexual Cases

Male Victim - Upper Back

Shoulder

Arm

Axilla

Penis

Scrotum

Breast

Female Victim - No documented cases

Assaults - Extremities

Thorax

Chest

Cheek (child perpetrator)

Others

Bite mark injury patterns in skin are normally preserved for analysis photographically. Rarely would a forensic odontologist have dental models of a suspect for direct comparison with the actual bite mark in the tissue.

The following items should be secured for examination at the scene or morgue:

1. Photographs
   Color
   Black & White
   Anatomic Landmarks
   Close-ups
   Each Arch (particularly curved surfaces)
2. Saliva Washings (for grouping)
3. Tissue Specimen (for microscopic examination)
4. Impression of Bite Mark (if appropriate)

A ruler should be included in a close-up photograph and the actual rule should be marked and retained as evidence with the case.

Oblique lighting is useful in bringing out the surface texture of the injury pattern. Care should be taken not to "burn out" detail with lighting.

Photographs of the bite mark without rulers or labels should also be taken and the field should be free of all debris or other extraneous material.

It is not possible to make a bite mark without leaving traces of saliva. Saliva should be collected for examination by the serologist. It is important that a protocol for collection of this type of evidence and control samples be agreed upon by the laboratory which will examine this evidence and the collection agency.

One accepted method by which to obtain saliva samples is to swab with 100% cotton threads moistened in sterile distilled water. A control sample should also be obtained from another part of the body.

In order for comparisons to be made the teeth and/or models of the teeth of the person suspected of causing the bite mark must be examined.

This examination should only be done with informed consent of the suspect or by court order. Specific items desired by the forensic odontologist should be enumerated and could include impressions, wax bites, photographs, and x-rays.

Court orders for dental evidence can be obtained by prosecutors during pre-arrest, pre-indictment, and post-indictment proceedings.[1]

The pathologist may resect the entire bite mark area or take small samples for microscopic analysis. He may determine grossly and microscopically whether the bite mark is a healed, healing, or new injury in relation to the time frame of the crime. Good color photographs may be used by the pathologist, forensic odontologist, or other competent expert to render opinions relative to the age of the injury.

In addition, other techniques can be used to reproduce those characteristics such as "rubbings" as used by Sperber.

> "Skin alterations are quite different depending upon whether the bite marks are inflicted just previous to death or very shortly afterwards, ...for some hours after death...the marks are relatively sharp. ...after some hours the bite marks are less easily seen or have become smoothed out. However, small haemorrhages (sic) may remain for a long time."

1 In New York vs. Lemuel Smith the court compelled the defendant to submit to dental examination for the purpose of seizing evidence to be used for bite mark comparisons.

> "The shrinkage of the corpse due to loss of water soon results in a difference in the size of the marks as compared with their appearance in the first few hours."

Evidence collected during the examination is interpreted by the forensic odontologist and a comparison made with the bite mark pattern in the tissue which now usually exists as a photograph. The basic question the forensic odontologist is trying to answer is, "Are the teeth of the person in question the common origin of the bite mark in the tissue and the comparison materials?"

The concept of class and individual characteristics used by Professor Osterburg in his book, The Crime Laboratory, can easily be adapted to bite mark evidence.

> "Class characteristics are the more obvious, gross features distinguishable in an object...With evidence involving impressions...the general dimensions, design, and contour of the imprint constitute the class characteristics."

> "Individual characteristics are attributable to several sources:
>
> 1. Natural phenomena...
> 2. Minor damage through abuse..,
> 3. More serious damage through misuse...
> 4. Uneven or accidental wear...

Applying Osterburg's description of comparisons to bite marks, the first step

> "is to determine if the class characteristics

in the crime scene (bite mark) and comparison photographs (exemplar bite) are similar and if there are any obvious or subtle discrepancies. If no differences are observed, attention is focused upon locating in each photograph those minute details which constitute the various individual characteristics..." This process is continued until no further individual details can be found."

"The recognition and distinction between class and individual characteristics is not always obvious or simple and sometimes is quite subtle...."

Class Characteristics of Teeth: The bite mark injury pattern is usually caused by the incisal or occlusal portions of the teeth. Generally they reflect the overall shape of those parts:

Incisors: rectangles

Canines: triangles and variations

Premolars: single or dual triangles, diamonds, variations

Molars: rarely mark, reflect shape of the portion involved

Individual Characteristics: All deviations from the basic are reflected as individual characteristics. For example, the incisor beveled by wear will

not cause the typical rectangular injury pattern but rather, may create small single or dual circular injuries connected or not connected by linear injury pattern.

Other Considerations: Occasionally the decision as to whether an injury is a bite mark is quite difficult. The finding of salivary enzyme could help prove the fact. However, the fact that salivary enzyme might not be demonstrated does not necessarily prove the injury is not a bite mark.

In the analysis of bite mark evidence the questions, observations, and opinions might follow this sequence:

1. Is the injury a bite mark?

   Factors: Ovoid or elliptical pattern

   Full or partial shape

   Includes "suck mark"

   Linear interrupted abrasion pattern (consistent with tooth sizes)

   Arch size consistent with dentition (or portion of dentition)

2. Is the bite mark human or animal origin?

   Factors: Arch form

   "Suck mark" present/absent

   Canine perforations deep/superficial

   Tissue tearing and laceration/superficial abrasion pattern

   Arch size consistent with human/animal dentition

   Individual tooth pattern consistent with human/animal dentition

3. Has the bite mark been made by adult or child?

   Factors: Arch size

   Individual tooth size

4. Which is upper arch/lower arch?

   Factors: Arch size

   Class incisor tooth size

5. Which teeth are represented?

   Factors: Class characteristics of types of teeth

6. Is individualization possible with reasonable dental certainty?

   Factors: Unique and individual characteristics

7. Can this bite mark be placed in the time frame of the crime?

8. Is the bite mark consistent with the type crime? e.g. sexual assault, assault, child abuse?

Conclusions reported by forensic odontologists are, as with all experts, opinions which are based on the education, training, and experience of the expert rendering them.

Basic forensic odontology conclusions include:

1. With reasonable dental certainty the bite mark in the tissue and the exemplar have been left by the same teeth. (A high degree of probability that the two bite marks have a common origin)
2. The bite mark in the tissue and the exemplar are consistent. (The bite marks could have a common origin. A meaningful conclusion because a single discrepancy will exclude a suspect.)

3. The bite mark in the tissue and the exemplar are not consistent. (Exclusion)

It should be noted that a positive identification is theoretically possible.

Developing Areas

Identification: The real problem in using dental evidence for identification is locating that evidence required for comparison. In the United States today a significant number of people have had dental examinations and care. There exists a vast amount of dental evidence which could be quite valuable for identification purposes. It is currently being minimally exploited.

California was the first state to enact legislation creating a repository for the matching of dental records of unidentified bodies with dental records of reported missing persons. Other states have followed suit. Attempts at creating a national repository for similar purposes are being made but the federal government, it would appear, would have to be the sponsoring agency for such a repository to be successful. At this time they have not indicated a willingness or desire to do so.

All other considerations aside, it might be argued that such a system would not be cost effective. Such an argument is not necessarily valid. We have no real idea of the current cost to investigative agencies, coroner and medical examiner offices, and society in uncovering dental evidence.

Certification and Availability of Experts

A significant problem for the law enforcement and legal communities is finding competent experts in forensic odontology.

The two major organizations where forensic odontologists can readily be found are The American Board of Forensic Odontology and the Odontology section of the American Academy of Forensic Sciences.

The American Board of Forensic Odontology is an independent organization which certifies the competence of forensic odontologists. Basically, an applicant will present his credentials to professional peers. If the applicant fulfills published criteria relating to education, training, experience and character he will be allowed to take an examination. Those passing the examination and fulfilling any other criteria are certified as diplomates of the A.B.F.O.. At present there are forty-four diplomates throughout the United States and Canada.

The Odontology section of the American Academy of Forensic Sciences requires a dental degree, a formal course of instruction in forensic odontology (short course), active association with an agency engaged in forensic odontology, and over one year work experience to become a profisional member.

Various levels of expertise are required for the tasks that fall into the realm of forensic odontology.

A dentist with good clinical experience might be professionally competent to make a simple identification. Unfortunately, he might not have an apprecia-

tion of evidentiary procedures or, having made observations, not be able to make the fullest valid conclusion. That same dentist using "dental logic" in examining bite mark evidence might easily make tragic errors.

Forensic Dentistry has made significant advances in the last fifteen years despite the almost total lack of financial support for organized efforts in research. Had academic institutions, dental organizations, or governmental agencies funded research into significant areas the "state of the art" probably would have advanced even further.

Two of the major issues facing the forensic odontology profession relate to bite mark cases.

The legal profession has expressed concern that no published terms and standards exist for interpretation of bite mark evidence. There are no numerical standards for points of comparison such as those for fingerprint identification. Bite mark analysis currently depends upon the skill, knowledge and experience of the individual forensic odontologist.

The skills, knowledge and experience of the odontologist are of paramount importance in bite mark analysis. Efforts should be made to assure that the odontologist possesses the requisite expertise in bite mark analysis

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FORENSIC PATHOLOGY

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EXECUTIVE SUMMARY

Pathology is the study of the reaction of the body to disease. There are two major subdivisions.

1. Anatomic pathology: the study of the morphology or appearance of disease in an organ or tissue removed from a living body (e.g. a tumor removed from the breast or in all the organs and tissues in a dead body as in an autopsy or necropsy).

2. Clinical pathology: the study of body fluids (e.g. blood and urine) or the agents causing disease, (e.g. bacteria and viruses) or other similar examinations conducted in a hospital clinical laboratory.

Academically, forensic pathology is defined as the application of the science and methods of pathology to the resolution of problems at law. Practically, forensic pathology is the application of the methods of both anatomic and clinical pathology to the study of unnatural diseases, such as the effects of physical injury from trauma, heat, cold, electricity or chemical injury from drugs and poisons. In a broader sense, forensic pathology also includes natural diseases which may by transmission pose a hazard to the community, and the effects of the environment on the body.

There are two common misconceptions concerning forensic pathology: 1) that the medicolegal autopsy can stand alone as prima facie evidence of the cause and manner of death, and 2) that the medicolegal examination conducted by the forensic pathologist commences when the scalpel is picked up and concludes when the body is released to the mortuary. Actually the

autopsy is only one step in the medicolegal investigation of death. The entire sequence may be summarized as follows:

1. Reporting of the death to the coroner or medical examiner.

2. When determined necessary, on-scene investigation, evidence gathering and documentation often conducted in conjunction with other agencies, particularly the law enforcement.

3. The performance of those steps necessary for identification of the remains.

4. The performance of a medicolegal autopsy which, depending upon the nature of the case, may include some or all of the following:

a) Visual examination, description and documentation of the clad body as received.

b) Same steps as a) on the unclad body.

c) Same steps on the dissected body.

d) Collection of evidence from without the body for examination by the physical science laboratory.

e) Collection of organs and tissues from within the body for ancillary examination:

- Histopathology (microscope study).
- Toxicology (analysis for drugs or poisons).
- Serology (blood grouping and/or enzyme typing).
- Microbiology (bacteria or viral disease-causing agents.).
- Clinical pathology (abnormal levels in blood and tissue of normally occurring substances, e.g. sugar, proteins, etc.).

f) Consultation by other biological specialities (anthropology, odontology, entomology, radiology, etc.) in selected cases.

g) Review of medical history, social history, work history, etc. in selected cases.

h) Preparation of the report including objective description of findings, and correlation of the findings from investigation,

pathological, ancillary examinations and consultations in order to officially certify the cause and manner of death. (See Appendix A for a sample autopsy report.)

Forensic pathology is not satisfactorily practiced as a separate pursuit; rather the forensic pathologist works best as a member or leader of a multidisciplinary team charged by local or regional statute with the medicolegal investigation of all known or suspected unnatural deaths and usually all unattended, unexpected deaths as well. The forensic pathologist then, with few exceptions, works directly or indirectly for a coroner or medical examiner, or directs such a program. As such, he or she is essentially the medical component of the medicolegal investigation of death, or autopsy. The rest of the team may include toxicologists, physical anthropologists, forensic odontologists, and those in the forensic physical science laboratory who are called upon to conduct physical, chemical and serological examinations on evidence collected either from the exterior or interior of the body. Collection of such evidence is an integral part of the medicolegal autopsy.

Certification of a specialist in forensic pathology by the American Board of Pathology, the agency charged by the American Medical Association with such certification, begins with one of the following training programs: two years each of anatomic and clinical pathology, followed by one year in forensic pathology; three years in anatomic pathology followed by one year in forensic pathology; or two years each in anatomic and forensic pathology. After training, a written and practical examination in anatomic and forensic pathology must be passed. Absent the requisite training, extended periods of appropriate experience may be sustituted, after which a pathologist may be certified as a forensic pathologist

by successfully completing this examination.

In these days of tight budgets, one of the easiest places to cut is the funding of coroner/medical examiner programs. Cuts are made here largely because these programs:

1. Are usually not visible to the electorate, and often not noticed by the elected.

2. Are believed, incorrectly, to be concerned only with the dead.

3. Are often believed, again incorrectly, to be involved almost exclusively with the lower socioeconomic strata of the community.

4. Have never independently conducted a cost-benefit analysis to determine the cost effectiveness of a quality medicolegal investigative system.

Actually, many sectors of the community benefit from well-run programs which aid in obtaining accidental death insurance or workman's compensation benefits. Table 2 outlines some of the benefits of having a comprehensive system and some of the consequences of having one.

To cope with this lack of local funding, plus the demand for more sophisticated medicolegal examinations and reports, various changes, and some problems, have surfaced in the field of forensic pathology. These include:

1. A decided trend away from a local, non-physician official elected as leader of medicolegal investigative systems, toward a physician (usually a forensic pathologist) appointed as leader of the statewide system.

2. A less decided, but still recognizable, trend toward association of medicolegal investigative systems with medical colleges.

3. A recognizable trend toward the inclusion of specially educated

and trained paraprofessionals to assist the forensic pathologist, usually in the preliminary investigation or in the more mechanical steps of the autopsy.

4. A diminution in the number of physicians seeking special training in forensic pathology, and of those trained.

5. A rather striking increase in the number of those practicing forensic pathology as a part of a larger private practice of pathology.

6. Fewer experienced forensic pathologists to fill full-time public positions.

CAPABILITIES AND LIMITATIONS

The capabilities and sometimes the limitations of forensic pathology are determined by two major areas: the system in which it is practiced and the difficulties inherent in the discipline itself.

The system is defined by the scope of the enabling legislation and the resources provided by the community to carry out these responsibilities. Within the United States, the spectrum of capability in each of these categories, from one community to the next, extends virtually from nil to near optimal. Whereas most of the agencies with such responsibilities operate at the county level, even in those states in which there is statewide legislation, the legistlation implementing and providing for broad policy, including the method of selection and qualifications of individuals directing these programs, derive usually in state statute. In some states such statutes may be modified by local option. Budgetary provision for support of most of these systems is derived largely at the county level, although shared with state resources in some jurisdictions. In only one or two states does state appropriation provide all of the resources for the medicolegal investigative system throughout that jurisdiction.

Local interpretation of rather broad and general legislation, particularly with respect to the requirements for reporting and acceptance of jurisdiction is often determined by the resources available within the counties throughout large portions of the United States. Notwithstanding the implementing legistlation within the state charters, those deaths investigated by the medicolegal investigative system, which in such areas is largely a coroner's system, are sometimes limited to only the very overt unnatural deaths wherein a criminal act is known or suspected.

Under these circumstances, the investigation conducted is ofen limited to that provided by a law enforcement officer designated for these purposes as a deputy coroner.

Often resources are only available for the community hospital pathologist to conduct autopsies in those instances in which a suspect is in custody, criminal litigation in contemplated, and the examination is necessary either to assure the anatomic cause of death, or to obtain evidence from within the body for subsequent use in this litigation. Under these circumstances, the local coroner, usually elected, occasionally designated by the county commissioners, is afforded only minimal remuneration for his inconvenience in overseeing this interaction between the law enforcement, pathologist, and district attorney ultimately using such evidence.

In several states there is a requirement that the coroner be a physician. However, his or her remuneration may not be substantially greater than that of a non-physician in other states. Likewise, only marginal resources are afforded either for investigation or for payment of the community pathologist performing those examinations considered absolutely essential.

At the opposite end of the spectrum, within the large population centers of the United States, medicolegal investigation is considerably more sophisticated. In some states although coroners are used in rural areas, provision has been made for designation of pathologists as the directors of medical examiner systems. These agencies usually employ a range of staff from forensic pathologists to lay investigators trained to do preliminary reports of unattended, unexpected or unnatural deaths and to examine scenes of deaths they consider necessary. On the staff are also usually other specialists either employed by the program or provided by a central governmental laboratory servicing several agencies. Other

specialists available usually as consultants include forensic anthropologists and odontologists. Within the framework of the government supporting such a system is usually a forensic physical science laboratory. Only in rare instances is this integrated into the medicolegal investigative system. Most such laboratories, which examine the evidence derived from the body not examined by other disciplines, are an intergral part of the law enforcement agencies, and those practicing therein are commonly known as criminalists.

Whereas one might expect the budgetary resources available for the development and maintenance of medicolegal investigative systems within these large metropolitan areas to be commensurate with the heavy workload resulting from increased violent crime, in reality such is not the case. This has already had rather dire consequences on the recruiting of qualified professionals into the field of forensic pathology.

This curtailment of resources represents the reversal of a trend. Approximately 20 years ago, the medicolegal investigator became concerned, not only with the performance of examinations on the victims of violent crime, but also with the recognition and quantification of a host of other community problems. In one large city, this included the study of such community hazards as the imbibing of non-ethanol beverages by the chronic alcoholic population and the needless deaths occurring in emergency rooms as critically ill or injured persons waited for treatment because noncritical cases were being cared for. Again, in many of the more sophisticated, large metropolitan jurisdictions, personnel and support resources were such as to enable the forensic pathologist practicing there to spend a portion of his time keeping abreast of the discipline by review of the literature to which he could occasionally contribute his own unusual cases. Fortunately or unfortunately, depending upon one's perspective,

during that period of time resources for defense of the suspected perpetrator were not nearly as available as they are today, and the forensic pathologist's findings and conclusions were often unchallenged. Consequently, the time spent in report preparation and presentation in court could be considerably less than currently necessary in many of the more sophisticated jurisdictions where public defenders may have a knowledge of the nuances of forensic pathology. These knowledgeable defense attorneys not only exact more sophisticated reports and documentation, but also require time for consultation prior to court and sometimes even consultation by forensic experts from other jurisdictions. There is little question that such interaction between forensic pathology, or any of the forensic disciplines, and those utilizing it in the criminal and/or civil justice arena, results in better evidence collection, documentation, interpretation, and more impartial litigation.

The near-optimal resources and manpower in several large jurisdictions in the United States have made such extensive interaction virtually standard operating procedure. Even here, however, the resources afforded to meet the increasing incidence of violent crime and the increases demand for sophisticated pretrial workups have rarely kept pace with the inflationary component of the agency's budget. Community agencies capable of rendering descriptive reports 10 years ago, in several instances have been forced to reduce their findings to mechanical checklists which almost invariably preclude objective interpretation of the findings by experts other than the original examiner. This has occurred in spite of the fact that the significance of such findings may substantially affect the outcome of civil litigation amounting to millions of dollars in any one individual case, or in criminal cases resulting in retrial or case dismissals

because of inadequate or inappropriate evidence. Again, such retrials may ultimately cost the communities millions of dollars, while such dismissals place back into the community individuals who would have been confined had adequate medicolegal investigation and examination been conducted.

Careful, conscientious decision-making is necessary to determine: 1) in which instances the scene of death must be investigated and documented; 2) in which instances a medicolegal autopsy must be performed; 3) in which cases to conduct ancillary examinations including histopathology, toxicology, anthropology, odontology or other specialty examinations. If the resources necessary to perform these functions by experts skilled in the field are available, one might expect any given medicolegal investigative system to have reported to it in any given year approximately 30 to 35 percent of all of the deaths occurring within their jurisdictional area. Table 1 is a list of reportable deaths considered unattended, unexpected, or known or suspected unnatural, similar to that currently used in several systems. The statutory responsibility of the agency may extend from the investigation and examination of only deaths in which a criminal act is suspected, to the opposite extreme, the reporting, examination and accurate certification of deaths in virtually all of these categories. In those jurisdictions wherein the medicolegal investigator is allowed to limit the scope of examination commensurate with the resources provided for such examination the prudent director of such a system would do well to carefully examine his criteria for examination in such a way that, as the resources available are curtailed, the list of reportable cases may be trimmed to exclude those cases of least public interest and the list of those cases in which routine medicolegal autopsy is performed is similarly

curtailed to include those cases of maximum public interest.

Unfortunately, in many established programs bound by tradition within their community, the directors have been forced to dilute their endeavors such as to preclude an in-depth medicolegal examination with qualified ancillary professional support in many, if not most, of their cases. The practicitioners of forensic pathology within these extablishments have often been forced into a position of performance of rather routine, mundane, examinations, not only on the victims of criminal acts wherein such an examination is unquestionably of value, but also on the victims of motor vehicle accidents wherein such examination often amounts to little more than a cataloging of injuries in a victim whose fatal accident was rather readily demonstrated to be caused by the influence of ethanol. Often the findings of such an indepth examination have been proven to be unnecessary either for accurate certification of death, or even subsequent civil litigation inasmuch as the cause of death is rather readily apparent and the age and apparent good health of the victim preclude the need for such examination.

Again, in any large category of such cases, experience and individual judgment is necessary to determine in which instances such an examination should be conducted. In many large jurisdictions wherein neither trainees nor full-time practitioners are available, largely because of the unavailability of resources to provide a competitive salary or the ancillary examinations and support necessary for a quality practice, the examinations resulting are considerably less than optimal and rarely afford the degree of precision necessary for the practicioner to sit through a lengthy deposition such as is frequently encountered in preparation for wrongful death civil action. The embarassment resulting from such inability to prepare

properly for such an examination, whereas the capability of the science itself may extend into most, if not all, of the areas of questioning posed, is another one of the reasons leading to difficulty in recruiting within this rather challenging subspecialty.

Given the importance of the setting in which forensic pathology is practiced, several leaders of large northeastern medical examiner systems in the early 1950's joined forces with several leaders within the National Municipal League. Among those who figured prominently in early discussions which have ultimately lead to the establishment of the National Association of Medical Examiners were Richard S. Childs, from the National Municipal League, and Milton Helpern, then medical examiner of New York City. One of the earliest efforts of this group was the review of then existing medical examiner agencies and statutes and the promulgation of "A Model State Medico-Legal Investigative System." Unfortunately, many of the early efforts of this organization were directed toward a sweeping change of all local medicolegal investigative systems from elective coroner to appointive physician/pathologist medical examiner systems. Important elements of that model were the provisions to be contained within legislation creating or enabling a medical examiner system and a listing by definition of those deaths which should be reported to such a system under ideal circumstances. This organization has more recently undertaken the accrediting of medicolegal investigative systems.

The second area of limitations in forensic pathology are those which derive from the nature of the body's response to injuries of various types, including the tremendous individual variation thereof, and the overwhelming limitations of resources, both funds and manpower, with which to address this virtually cataclysmic degree of ignorance. To a large degree this

dilemma results from the mores of the community at large ultimately translated to the mores of the medical community within which the pathologist and forensic pathologist practices. For example, one rarely reads any daily newspaper within the United States without seeing reference to some recent research finding, however inauspicious in and of itself, in those areas of disease which the community has interest largely as a result of government interest and research support. The words "heart attack," "cancer," and "stroke," for several decades now have been virtually coexistent with the names of the institutes allocating major funds for medical research. One has but to review the four-year curriculum of the vast majority of medical schools in the United States to convince oneself of this impact, which virtually ignores trauma and the effects of the ethanol and drugs which result in a major portion of that trauma. This is in spite of the fact that, as early as the Korean conflict, it was substantially demonstrated that prompt medical attention by reasonably trained and supported paramedical personnel, and rapid transportation to primary care centers staffed by physicians specially trained to deal with the effects of such trauma, reduced deaths to a fraction of former totals and eliminated complications and sequelae in a substantial percentage of the survivors. Notwithstanding, support for the recruitment and training of such paraprofessionals, transportation of victims injured, not on the battlefield but on the highway, and the development of the subspecialties of traumatology, into which forensic pathology might have substantial input if professional workloads permitted such interaction, have been supported at token levels by the federal health agencies.

There is hardly a day that some user of information gleaned by the forensic pathologist in the course of his regular practice does not ask a question which this subspecialty has not had a chance to explore. Among

these are many which might be answered with relatively modest research efforts and many which very definitely should have been answered in depth many years ago. Included among these are such basic questions as the amount of force necessary to fracture bones in extremities or the skull, the variations in the time wherein basic cellular responses to various types of injury occur and much more precise information about the effects of age, nutrition and a host of other factors which might significantly affect the body's response to injury and thereby the pathologist's interpretation of the age of such injury. Forensic pathologists for years in virtually every large municipality in the United States have collected and preserved small pieces of tissue as routine measure. With rare exception have any of these tissues been examined for subtle morphological alterations which might be associated with variations in environmental exposure from one community to the next.

DEVELOPING AREAS

Trend away from local non-physician elected officials as leader of medicolegal investigative systems

Many government levels throughout the United States have been observing both the old, long established medical examiner systems in the northeastern United States and the more recently established systems scattered rather sparsely throughout the remainder of the country with the notable exception of the midwestern states and California. Among these are several large urban municipal programs. One observation which has become increasingly apparent as the new systems have developed is that not one single method, either for transition from existing incumbent coroner systems or maintenance of quality medical examiner and medical investigative systems, has been able to meet the needs or expectations of all these various geographical populations.

Among those considerations which appear to have the greatest influence on this transition are the size of the political subdivision to be served, the nature of the positive or negative support for such a transition from coroner to medical examiner (which consideration plays a major role in the availability of financial support for the program once enacted), and the degree of sophistication exacted or expected from such a medicolegal investigative system once the implementing legislation has been enacted and funded. It is not within the scope of this presentation to discuss in detail the many variations of these systems. Suffice it to say that in programs serving large geopgraphic areas, there may be inherent difficulties in communication for those responsible for initial investigation and subsequent examination, in transportation of remains, in accruing resources

provided with remuneration commensurate with the quality of the examination they are expected to conduct in support of such a program, has met with success, particularly in groups where one or two of the members have had special training and maintain special interest in forensic pathology.

Support for medical examiner programs from other professions varies. Funeral directors, in spite of how much concern is afforded their need to obtain the remains promptly in order to provide quality preparation for preservation and cosmetic reasons, are usually inconvenienced to some degree by medical examiner programs. There are a number of reasons for this. In the past medicolegal autopsies have been conducted on remains embalmed by the funeral director prior to examination. Such a procedure precludes satisfactory collection of trace evidence, except for perhaps the retention of clothing. It also precludes performance of any microbiological examination or most toxicological assays except perhaps those which may be performed on a blood sample, which, depending upon the skill of the mortician, may or may not be contaminated by embalming fluid. In the larger geographic jurisdictions, the facilities of the morticians may be necessary for local retention and examination of remains when medicolegal autopsy is not performed. The morticians may be called upon to assist in the transportation of these remains if an autopsy is to be conducted. All of these factors, together with the delays which may result, whether or not an autopsy is conducted, and the uncertainty in scheduling services made necessary by such inconvenience, have tended to engender negative support for such programs from this profession.

Since the magnitude of the inconvenience to the rural mortician is often greater than in the urban and suburban areas, this group, even in some

of the most sophisticated, best supported and administered programs, often would prefer to go back to "the good old days." Their urban and suburban counterparts, less inconvenienced, are usually much more supportive of the well-adminstered program, recognizing that the value of the quality investigation, examination, and certification obtained offsets the immediate inconvenience to them and the families of the deceased.

The law enforcement community will often express ambivalence toward programs largely because it fears interference with its functions, particularly at the death scene. Another of its concerns is interaction with the media between the various agencies, particularly when the local law enforcement leader served in an elected capacity. However, when program representatives do not meddle with the death scene and do not make public statements when criminal investigations are underway, but provide quality, timely reports wherein the questions asked by the law enforcement agencies are answered in language they can understand, these agencies, as with the public prosecutors, are a source of continuing support.

The medical community outside the speciality of pathology may be counted on to offer support for a medical examiner or medical investigator program, sometimes without completely understanding its expectations of such a program. Sometimes its expectations are unrealistic, such as the desire to use medicolegal autopsies to sophisticate diagnoses in cases not covered by the scope of the program. The denial of such an autopsy may alienate a local physician from the system. However, if a well-adminstered program recognizes the need for daily interaction with a large segment of the community attending reportable deaths and will provide physicians with quality and timely reports of the circumstances, examination findings, and method of death

certification, it will continue to receive the support of the rest of the medical community.

The reaction of incumbent coroners and the organizations they have created to a proposed medical examiner program may be predicted, given the reactions of the various professional groups as discussed above, and given the nature of the qualifications of the coroners within these jurisdictions. If a substantial percentage of the county coroners in any given state are funeral directors and/or elected law enforcement leaders, the political leaders in that area should not expect universal support for such a transition. These groups, by the very nature of their service, interact in a very politic way with the community. Membership in Kiwanis, Rotary and other service clubs is the rule, and their resistance, whether as a large, organized lobby, or as a quiet visit to their local legislator, is almost universally met unless it can be demonstrated that their practice will be ultimately benefited to greater degree than it is inconvenienced. Those proposing new programs would do well to recognize that the potential inclusion of many members of this group as local representatives of a larger program, charged with investigative responsibilities, and afforded the training and expertise necessary to carry out the local decision-making responsibilities, will go a long way in gaining the support necessary for enactment of legistlation by these professionals with so much local political clout.

Those contemplating change in their system would also do well to look very carefully at the cost of implementing new legislation and particularly at special, often large expenses which result when large geographic areas are provided with such service. Included should be the cost

of reimbursing the local representative, whether he be a physician or not, the cost of transportation of remains if the examinations are to any degree centralized, the cost of providing transportation to the pathologists offering testimony in the various court jurisdictions, and the cost of ancillary services (such as toxicology and physical science laboratories) which had heretofore not often been afforded to the local medicolegal investigator. The start-up costs may also include a central examination facility with refrigerated storage of bodies transported there for examination. If regional pathologists are to assist in such a system, adminstration must carefully explain the nature of the examinations expected of them, including documentation, physical evidence, and specimen collection for any ancillary examinations to avoid any possible misunderstanding. Program cost projections must be sure to include remuneration commensurate with the level of service expected of these professionals.

Trend toward identification of local and regional medicolegal investigative systems with medical colleges.

Even in the past decade, prior to the substantial curtailment of their federal support, there was a need for medical schools to have increased visibility throughout the community and state in which they were located. Likewise, there has been a decided trend in federal support for research in applied science extending virtually across the spectra of the disciplines found in a large university. This research covers the interaction between the human and his environment, which conceivabley includes every agent and device with which he comes in contact. The methods of such study, and often the finite determination of the results of such interaction, have led to more in-depth exploration of physiological and pathological changes within

the body and increasing utilization of organs and tissues for a host of biological examinations to include increasingly sophisticated pathologic studies utilizing methods and instrumentations far beyond the scope of the light microscope and even the electron microscope. It is not inconceivable that computer-assisted morphometric comparison of tissues recovered from large numbers of postmortem examinations of individuals exposed to different ambient levels of "unnatural" contaminants placed into the environment by man will be used to detect subtle morphologic alterations deriving from such exposures.

These factors, with the decided recruiting advantage of such programs deriving from the "revelance" of this type of pathology practice to the community as a whole, and the rather decided increase in professional prestige and intellectual stimulation, combine with other factors such as the interaction with other medical and non-medical disciplines to make such a relationship attractive. The opportunities for research and teaching afforded the forensic pathologist working closely with the academic community has resulted in the enticement and retention of practitioners whose day-to-day service endeavors are often of a substantially higher quality than those of many colleagues carrying out full-time forensic pathology in establishments isolated from the academic community.

However, it should be pointed out that such association is not without some disadvantages, including the need to adhere to much of the parochial adminstrative routine inherent in the educational system. One solution to this problem is to locate the medicolegal investigative system within the academic community, but to have it administratively and financially supported by another element of local or regional government. The difficulty

with this solution is that any director of such a program, with each foot in a separate administrative component, is ultimately going to find himself compromised to some degree by one or the other. Even in those affiliations in which administrative control of the unit rests outside of the academic community, there may be incremental appointments to the full-time faculty, providing a percentage of the pathologist's salary. Such appointments as a general rule do not afford tenure, but do exact a level of teaching and research commitment comparable to those on the full-time faculty, but at the incremental level supported. The degree to which promotion and tenure committees within the medical college recognize the contribution to service, as well as teaching and research, varies considerably from one school to the next although there has been an attempt to keep the salaries of those with heavy administrative and service duties in the academic departments more comparable with their colleagues engaged in full-time practice outside the medical community. There is little question but that any requirement for research and teaching, added to the already overwhelming service requirements exacted of many forensic pathologists would serve as a block to their consideration of such an association.

On the other hand, were such agencies to be staffed with a sufficient number of professionals to afford each the opportunity to engage in some teaching and research in addition to the service responsibilities, there is little doubt in this writer's mind that the opportunity for the young doctor to observe the forensic pathologist working and receiving the recognition of his academic colleagues would substantially improve recruiting in this field. Among the programs closely affiliated with or incorporated into the academic community within the past decade are North Carolina, Tennessee

Rhode Island, and New Mexico statewide programs, and at the community level, Miami and Dallas. Among those that have disaffiliated or completely relocated administratively or physically outside the medical school are statewide programs in Vermont and Oklahoma. Association between medical schools and governing political units is being explored in Arizona and Massachusetts. Virtual daily interaction between members of the forensic pathology academic and political community makes this a constantly changing scene. A substantial percentage of the forensic pathologists engaged in full-time practice who are located near schools of medicine, whether or not any formal interrelationship exists between them, holds various types of academic appointments, some of which afford no regular opportunity for classroom instruction or association with residents in their early years of training in pathology. Others are called upon regularly to present instructional blocks within the core curricula in pathology or to provide electives in forensic pathology to upper division students or residents in local pathology training programs.

Increasing utilization of paraprofessionals in medicolegal investigative systems.

In addition to the traditional professions which work as a part of the medicolegal investigative team, such as toxicology, anthropology, and odontology, and the cadre of technical staff who work in a modern medicolegal pathology laboratory, much as they do in a hospital morphology or clinical laboratory, there are two support roles filed by paraprofessionals. The medicolegal investigator and, a relative newcomer, the medicolegal pathologist's assistant.

Medicolegal Investigator.

As early as the 1960's, several leaders in large metropolitan medicolegal investigative systems saw the advantage of more formal education and training for a cadre of medicolegal investigators who reported directly to their agency rather than to a law enforcement or other government agency. Formerly it was commonplace to rely very heavily upon the services of retired law enforcement officers; now, the trend is requiring an academic degree in addition to investigative experience. Limitation of resources has considerably curtailed the pace of this trend, the merits of which many, if not most, experienced medicolegal investigators recognize. In such a system, an educated and trained medicolegal investigator serves as the forensic pathologist's eyes and ears at the scene. Unlike the law enforcement officer who has a very vital role in evidence gathering at scenes of death wherein only subsequent criminal litigation may prevail, the specially trained are able to make decisions concerning jurisdiction, the need for scene investigation and documentation, the nature of evidence to be gathered in noncriminal cases, the essence of hospital and medical practice and the records therein, and the need for medicolegal autopsy and/or collection of samples for ancillary examination. The National Association of Medical Examiners has recently published national standards for this group in order to facilitate the geographic relocation of its members. With their credentials will come recognition of their professional contributions. In some of the more sophisticated programs, they have already demonstrated their value in observing and recording physical findings at the scene which later may assist the pathologist in determining such details as the time of death.

Medicolegal Pathologists' Assistant.

The role of the pathologist's assistant is considerably more controversial. This highly educated and technically trained associate of the pathologist may carry out many routine mechanical procedures without actually making technical observations, preparing reports or interpreting findings. These paraprofessionals have already demonstrated their merit in the private practice of anatomic pathology; their contributions are potentially much greater in modern medicolegal investigation as there are infinitely more detailed mechanical procedures involved in the evidence gathering steps of a medicolegal autopsy. The danger exists, however, of the pathologist allowing their reponsibilities to extend beyond these mechanical steps. Therefore, the role of a pathologists' assistant, or morphology technician, needs to be strictly defined and limited to assisting the forensic pathologist. Some leaders in the field fear that the workloads of many forensic pathologists, together with the geographic distribution of their case material, will invite misuse of such paraprofessionals. This danger, however, should be weighed against the rather widespread use of "dieners" with considerably less if any formal education of training except as afforded at their place of employment. These technicians may perform most, if not all, of the technical procedures in a medicolegal autopsy, often undersupervised, and may opine over the telephone an immediate cause of death which is used for certification. The justification offered for using such individuals in this setting is that gross and microscopic specimens collected in the course of their procedure are reviewed later at a more central location by a pathologist. Some criticism of these paraprofessionals by professionals in the field is probably subtly associated with the undercutting of their rates of remuneration for performing these routine

procedures. Unfortunately, this attitude is hindering the development of more paraprofessional training programs.

As with the medicolegal investigators, a national agency for certifying pathologists' assistants has been formed within the last decade. This organization, American Association of Pathologists' Assistants, reviews credentials and offers examinations to members formally educated in this field of endeavor.

An increase in the number of those practicing quality forensic pathology in a private setting.

Most private practitioners of pathology recognize the merit of involvement not only in the hospital in which they practice, but in the entire community. However, most in the past have had little or no opportunity to acquire any formal education in forensic pathology except in a full-time fellowship or in several-hour short courses or weeklong seminars. With such limited exposure, many, such practitioners feel ill-equipped to handle the in-depth medicolegal investigations required today. Therefore, resident physicians with experience in forensic pathology during their regular four-year training program have found themselves in demand by group pathology practices willing to allow them to spend a substantial percentage of their time engaged in the quality practice of forensic pathology. Some group practices have even purchased special equipment and provided a paraprofessional staff with the apparent motivation being simply community recognition. These pathologists recognize that forensic contributions have considerably more public visibility than most of their practice, which is behind the scenes. A number of national leaders in the private and academic pathology community have taken note of the rising interest in forensic pathology electives which, in turn, has served to increase the interest of the academic pathology

community in forensic pathology.

Availability of improved technology for report preparation, data accumulation, management, and availability.

Many forensic pathologyists directing medicolegal investigative systems throughout the United States have the attitude, "If we can't get money to buy scalpel blades, how can we possibily get money to buy a computer for our program?" Most of these systems consider the produce of their efforts to be a case folder or jacket containing the reports of all of the investigation and examinations conducted on that particular case. Even in this situation, word processors can substantially reduce the cost of report preparation by obviating a complete second typing of any report.

Furthermore, this false economy overlooks the broader application of medicolegal date systems. Not only can data on local deaths be quickly and easily accessed, this data can be combined in to generate a summary of the total number of deaths with a certain jurisdiction according to cause and manner categories, which can then be correlated by geographic area, month, race, the presence of alcohol, and a number of other factors. Many of these programs have the computer capability to access much more of their data and make themselves much more visible by responding quickly to a host of questions posed by other government agencies, the media, or researchers looking for a more complex interaction between factors than is readily provided by the routine data synopsis.

Examples of "routine printouts" provided by one such data base to outside users include: a monthly summary of each known or suspected suicide to the local mental health agency, with return information concerning psychiatric history; a monthly listing of all deaths to the central police agency to close out records; and a weekly listing of alcohol related vehicular fatalities by age, sex, nature of accident, and level of alcohol. The legislature may be provided printouts used in-house for management purposes including weekly listing of pending toxicology cases as yet uncompleted and unfulfilled requests for autopsy reports listing weekly.

Greater Availability of Quality Ancillary Professionals to Forensic Pathology.

Historically, forensic toxicology has kept pace with forensic pathology in most of the larger, more reputable medical examiner programs. Unfortunately, the development of new programs particularly those serving large geographic jurisdictions, has created a shortage of individuals with appropirate education, training and experience in postmortem forensic toxicology. To a large degree, this is due to the limited number of opportunities available for doctoral level education and experience in postmortem forensic toxicology. Such education is limited to a handful of centers in the United States, including the Universities of Indiana and Utah. There is a decided trend to combine the practice of postmortem forensic toxicology with other special interest areas such as clinical and environmental toxicology so that a single toxicology "center" may not only study postmortem toxicology, but also assay environmental samples, and monitor therapeutic drug programs and methodology development. The center may also aid in clinical toxicology performed on or in behalf of living patients suffering from the toxic manifestations of either a therapeutic agenct or an outright poison.

As with toxicology, the disciplines of anthropology and odontology have developed a limited number of formal degree programs, and a series of regular short course offering to enable the scientist with primary education in one of these fields to practice in support of a forensic

pathologist, usually in consultation with an expert certified in the subspeciality. Certification is obtained through the American Board of Forensic Anthropology or the American Board of Forensic Odontology. These two boards, with the board in forensic toxicology, were created under the aegis of the Forensic Sciences Foundation with funds made available through the Law Enforcement Assistance Administration and the National Institute for Research in Criminal Justice. While experts in these two disciplines are usually found only in large urban areas or universities supporting forensic pathology training programs, much of their practice consists of reports prepared on specimens sent to them, and, as needed, travel to testify in court wherever subsequent litigation may be conducted.

Although no formal training program in forensic radiology exists, the increased interest in forensic pathology and the demonstrated value of radiology to this discipline are attracting members of this medical specialty in most large urban areas.

Special Training and Education Programs and Other Aids for the Part-time Practitioner of Forensic Pathology.

Several short courses have been a regularly available to residents and part-time practitioners of forensic pathology who have not had an opportunity for formal training and certification in this subspecialty for more than fifteen years. This course offered annually in the fall by the Forensic Sciences Branch of the Armed Forces Institute of Pathology in Washington, D.C., offers continuing medical education credit and presents to the interested forensic practitioner as much of an overview of recent methodology and finds as may be covered in one week. A distinquished national faculty presents not only introductory material but, in many instances,

rather complex nuances involved in the investigations of gunshot wounds to iatrogenic disease. The practitioner is also introduced to capabilities of modern physical science and toxicology laboratories.

In more recent years, this introductory course has been augmented by a more advanced course offered by the Armed Forces Institute of Pathology and representatives of the Laboratory of the Federal Bureau of Investigation. Designed for the more experienced practitioner, this course concentrates more on scene investigation and crime reconstruction, physical evidence gathering and incorporates basic physical laboratory findings such as serology, comparison microscopy, routine drug screening and other trace evidence analytic procedures.

Several years ago, the Law Enforcement Assistance Administration gave funds to the Education Committee of the College of Amercian Pathologists for a number of three- to five-day regional seminars at critical geographic locations across the United States. This program afforded the busy practicing pathologist, engaged to a limited degree in forensic pathology, an opportunity for classroom pariticpation similar to that offered by the Armed Forces Institute of Pathology, again with a faculty of individuals whith longstanding experience in the practice of full-time forensic pathology. The American Society of Clinical Pathologists has for several years offered a preceptorship program to its members and guests, serving as the liaison between interested society members engaged in a similar part-time forensic pathology practice and centers wherein for a one week to one month day-to-day practical experience is augmented by formal class training. These training opportunities are in addition to the regularly approved residency training programs in forensic pathology already discussed.

Additionally all three of the national organizations in pathology, namely the International Academy of Pathology, the American Society of Clinical Pathologists, and the College of American Pathologists, offer short courses covering a broad range of forensic pathology topics from methodology of investigation and some of the documentation tools such as photography, to both introductory and advanced courses in the findings which might be expected in certain medicolegal entities. All of these short courses, several of which make available materials for self-preparation at home prior to attendance at the national meetings, offer continuing medical education credit.

Either the part-time or full-time practitioner will also find the annual meeting of the American Academy of Forensic Sciences and the semiannual meetings of the National Association of Medical Examiners of value in keeping abreast of developments, not only within their special area of interest in forensic pathology, but also in the ancillary disciplines. The American Academy of Forensic Sciences annual meeting includes not only forensic pathology, but subsection meetings which present recent developments in all of the disciplines with which the forensic pathologist must interact in conducting his practice.

Finally, another valuable aid for the busy practitioner has appeared in the last several years in the form of "Guidelines for the Medicolegal Investigation and Examination of Death." These guidelines are in essence a recipe for conducting on-scence investigations of death coming under the jurisdiction of the medicolegal examiner. A series of questions to be answered in the course of the investigation, or for the pathologist conducting the examination, a series of steps to be followed in the gross and microscopic autopsy, insures maximum

information to the medicolegal investigator. All of the numerous ancillary procedures, which vary according to the type of death, are also detailed in such a way that, if the recipe is followed step-by-step, the examinations are well-documented, all of the available evidence is collected, and a report which is of maximum value to the user is prepared.

Included with these procedures are the reasons for each step so that the part-time practitioners of forensic pathology, particularly those to whom a full-time forensic pathologist is not readily available for consultation, find these guidelines especially valuable in conducting their medicolegal investigations. (See Appendix 2 for examples of investigative and examination guidelines).

CRITICAL ISSUES

As discussed earlier, a legislative framework is critical to a successful medicolegal investigative program, although it must be remembered that leadership, and community support have as great an effect as the name of the agency and the scope of the legislation implementing and enabling it.

Suggested model legislation.

Those interested in developing new programs ought to give careful attention in designing their legislation to the following factors:

1. Administrative placement of the program in the government or educational entity most likely to keep it in perspective as a neutral investigative, fact-finding agency with broad public health and criminal-civil justice responsibilities.

Early attempts at legislation still persisting in the minds of many leaders within the forensic pathology community tended to seek placement of this agency as "independent," thereby precluding administrative or political pressures which might tend to probide a less-than-impartial investigation of any one death or goup of death. Supporters of that concept called attention to the possibility of coercion from political or professional leaders if, in impartial investigation, findings unfavorable to any part of the political, medical or other professional group were uncovered.

This author, as of this writing, has worked as the director of the pathology department in a large western elective coroner's office, within a large eastern medical examiner's office which was an integral part of the health department of that city, in a large statewide health department, and as a director of a state wide program which is an integral part of a state-supported university. To date, the only coercion he has experienced, in spite of all of these organizational affiliations, has

been from family members who desire, for either economic, social, or possibly religious reasons, that the manner of death of certain individuals be changed from suicide to accidental or unknown. In addition to this, during the early days of the western statewide programs, there was a tendency for well-intentioned physicians and lawyers to seek amendment of the medicolegal documents in such a way that families might receive insurance benefits from strictly accidental death policies. In both of those jurisdictions, upon recognizing that such certification would ultimately serve to render any certification by such a program meaningless, upon explanation of the program policy to "tell it like it is," and the benefit of such certification to all in the long run, these efforts were short-lived. One wonders to what degree those paying insurance premiums in jurisdictions with sophisticated medicolegal investigative systems support the survivors of individuals dying under questionable circumstances in the less enlightened portions of the country. One might also wonder why those who usually stand to gain economically as a result of such accurate certification, namely the large insurance carriers distributing such policies (with minimum weekly or monthly premiums) in rather wholesale fashion often to relatively low-income families, are not joined by the large, reputable insurance community in supporting quality medicolegal investigative systems to assure more equitable distribution of the benefits of policies other than for natural disease.

2. Appointed leader, pathologist, preferably with certification by the American Board of Pathology in forensic pathology, with administrative experience.

The provisions for appointment of this leader should be such that he is protected from interference in the performance of his official responsibilities from any political or professional group. The tenure

of this official should be for such a period as he satisfactorily performs his or her official responsibilities and removal should only be for cause.

3. Provision for reporting of appropriate types of death and penalty for failure to so report.

Recognizing the broad variations within the resources currently made available for medicolegal investigative systems, this portion of the statute, rather than providing a long list of individual types of cases to be reported should be broadly defined. Experience has shown that if reportable deaths are characterized as either unattended, unexpected, or known or suspected to be unnatural in any sense, the subsequent definition of detailed types of cases to be reported can be as comprehensive as the local authorities desire, depending upon the resources made available for investigation and examination.

There is a real danger in listing within the statute a seemingly comprehensive categorization of all types of reportable deaths when resources are not made available for the agency to conduct an in-depth investigation and examination of any one or several of these categories. Another inherent danger in such a listing is the tendency for the community to develop interest in selected types of deaths which may not have been listed in the initial legislation. In legislation with such detailing, it would be necessary to change the statute to include investigation of such deaths. Among the categories of cases defined in the listing of some of the more recent medical examiner or medical investigator systems with the broader provision for reporting of deaths are deaths from known or suspected iatrogenic disease, and deaths from known or suspected environmental exposure, be it short-term, occupational or long-term as a result of ambient exposure of residents of a community. Such categories are

readily added to the "rules or regulations" or "instructions" implementing statutes wherein reportable deaths are defined more broadly as suggested.

4. Preservation of scenes of death for coroner or medical examiner investigation.

Although this provision of the statute should be self-explanatory, the statute ideally should indicate that responsibility for the scene of death in those instances in which there is a suspected or known criminal act should be shared with the law enforcement agency in whose jurisdiction the death is discovered. Ideally, the "rules and regulations" implementing the statute should indicate that the responsibility for the body and accompanying evidence should rest with the medicolegal investigative system and its representative while the responsiblity for other evidence at the scene of such deaths is that of the local law enforcement agency.

In many jurisdictions, the law enforcement agency has traditionally conducted quality in-depth inquiries into some deaths other than those in which a criminal act is suspected including work-related deaths when the death appears to have been an accident, accidents in the home, or accidents in recreational facilities. Such investigation usually is conducted when the death is directly or indirectly the result of an illegal act other than intentional homicide and usually includes all drug-related deaths and deaths resulting from wreckless driving, driving under the influence of ethanol, or other improper conduct. In most communities, the law enforcement agency is also involved in the investigation of suspected suicides. However, the inquiry and the degree of documentation of these and other deaths without any related criminal act is sometimes less thorough than that of a criminal case.

It should be recognized by those creating or implementing new systems that law enforcement jurisdiction is rather jealously guarded, and that these agencies have spent considerable time and effort in the past decade improving the quality of their methodology for investigation of all types of crimes, not only homicide. Many, if not most, large municipal law enforcement agencies have rather sophisticated laboratories, equipped and capable of conducting the detailed procedures necessary for satisfactory physical evidence collection. Misguided meddling by an untrained investigator working for a coroner or medical examiner, just as untimely, misguided reporting of the circumstances of death to the media, may serve to creat friction between the two agencies. The role of each in the investigation should be understood. Ideal legislation, in addition to providing for joint responsibility of the scene, should provide for joint reporting, such that if the coroner or medical examiner first receives the report of death it should be his or her responsibility to insure that the law enforcement agency is made aware of the death at such a time that they may pursue their inquiry by inspection of the scene if so desired. Effective legislation does not attempt to define closely those circumstances in which such exchange of reports should ensue, but rather provides for interagency reporting even when the interest of the law enforcement community may be limited.

5. Responsibility for decision of which cases to be autopsied should rest with the most appropriately trained professional and should be only broadly defined in the implementing legislation.

Statutes which attempt to list those deaths upon which an internal examination or autopsy should be conducted have posed some real problems to professionals trained in this decision making responsibility or with broad experience concerning the ultimate outcome of such examininations,

whether the findings be positive or negative. As with the reporting of cases, provisions of the enabling statute outlining when autopsies are to be conducted should be general, thereby again affording the flexibility either community interest or availalbe resources may require. In this writer's experience, the best way to do this is to provide in the statute for the medical examiner or coroner to conduct autopsies "in the public interest." The "public" may be further defined within the rules and regulations or instructions further defining the statute, if so desired.

The word autopsy should be defined within the statute as its use varies widely across the country. Also it must be determined when an autopsy may be conducted in the public interest, without the authorization of surviving family members. Those either implementing new or amending previous legislation should consider definition of this procedure to include retention of those organs and/or specimens as may be needed for any ancillary examinations which may include histopathology, toxicology, neuropathology, anthropology, or odontology. Organs and tissues, themselves should be retained when they are to determine the cause of death and to assist in determining the etiology of infectious disease, the presence of ethanol and other drugs, and for subsequent civil or criminal litigation when the findings cannot be satisfactorily documented in photographs, X-rays, or other procedures. In at least one jurisdiction, the statute enables the medicolegal investigator, conducting examinations pursuant to statute, to collect specimens for ultimate transplant into living recipients. In most jurisdictions, such specimens are not collected under these circumstances but rather pursuant to the wises of the next of

kin, recognizing, however, that the examination per se is conducted pursuant to statue.

6. Certification of cause and manner of death by most qualified member of the staff.

Proponents of the coroner system for years have alleged that the determination of the anatomic cause or the pathological lesion responsible for death is a medical judgment, whereas the certification of the manner or mode of death is a legal judgment rather than an opinion. In many of those jurisdictions, the coroner is empowered to certify the entire contents of the certificate of death, this official being the only person or agency other than a licensed physician so empowered within that jurisdiction. Strangely enough, many of these proponents believe that presentation of the findings of a medicolegal autopsy as gathered by a pathologist, together with the findings of an investigation as gathered by a deputy coroner or other member of the staff, to a jury of peers of the deceased, represents an acceptable, if not necessarily the best, method of death certification. If there be any advantage whatsoever to this supposition, it is that these findings, as certified on a death certificate, represent the findings of a legally constituted inquiry of record, an inquest, which findings, therefore, may be less frequently challenged subsequently by a proceeding in a court of law that the opinion of the coroner and/or medical examiner as expressed without such formal inquiry.

7. Subpoena power.

Whether or not the medical examiner or coroner is empowered with provision for inquest, and whether or not such inquest is defined by local or regional statute, the legislation creating and enabling the

medicolegal investigative system should provide subpoena power for selected records, to be understood that this power, so utilized, should be only for the determination of the cause and manner of death, not necessarily to affix responsibility upon an individual or agency. It should be further understood that records gathered pursuant to this subpoena power not be made available to individuals or agencies with a private interest who should obtain such records in a manner prescribed by legislation covering their area of interest.

8. Preservation of appropriate records.

Most modern medicolegal investigative statutes provide for the preservation of the records of death investigations conducted at public expense. Many provide for promulgation of information gathered at public expense to other appropriate agencies, particularly district attorneys and law enforcement agencies, when the medicolegal investigative system encompasses a number of separate, smaller jurisdictions representing such agencies. Such regular reporting, much of which is of no interest to these local officials, ensures regular intercommunication and often ensures the support of these agencies for the medical investigative system, the scope of whose endeavors would otherwise not be nearly as well-known as they are.

9. Provision for financial resources commensurate with the statutory responsibilities.

Whether creating or revising the statutes for a medicolegal investigative system, those political bodies responsible should be made aware of the expense of establishing and maintaining a comprehensive medicolegal investigative system. They should especially be apprised of all of the individuals and organizations within the private sector which must in some way interact with the medicolegal investigator.

Among those often overlooked who frequently suffer the greatest incovenience in performance of their professional responsibilities are the licensed funeral directors and public carriers, to whom the death may be initially reported and to whom the family often looks for initial guidance soon after death. Timely accomodation of the needs of these professionals and reimbursement for their expenses in both time and facilities, together with prompt and accurate certification of the death in as timely a fashion as possible, considering all of the ancillary examinations and investigations which may be entailed, will go a long way in ensuring their support. For years most of these individuals have worked in jurisdictions without quality medicolegal investigation. They may not recognize the necessity or value of such examinations until they have had an opportunity to perceive a more equitable distribution of both civil and criminal justice from which they may gain substantially in the timely payment of bills for their services and the family's understanding of the cause and circumstances of death which they, as the most available resource immediately after death, may be called upon to explain.

10. Provision for a board representing primary users of the medicolegal investigator, and/or a committee representing agencies interacting with the medicolegal investigator.

In many statutes, a board, generally comprised of leaders or representatives from government health, and law enforcement agencies and legal or public prosecutor communities, is the initial agency created by the legislature and subsequently charged by statute with the appointment of the medicolegal investigator, the determination of program policy and its method of implementation, the setting of fees charged and/or paid for services rendered by or for the medicolegal investigator, and the approval

of budgetary requests for funds with which to carry out the program. With such responsibilities, this board should ideally be constituted of interested individuals delineated by position rather than name, willing to spend the time necessary to become knowledgeable about medicolegal investigative systems in general and the needs of their community specifically, and willing to interact either directly or by respresentative with all of the other constituent and special interest groups which either regularly or on occasion interact with the medicolegal investigator. With this understanding, such a group may interface with the legislative body creating the statute, as well as with the many constituent groups with whom the medicolegal investigator must ultimately reach a working relationship in order to effectively carry out his or her responsibilities. Unfortunately, a number of vocal, longstanding leaders of the profession feel that such a board is ineffectual, largely because those designated to sit on it have either not had an interest or understanding of medicolegal death investigation or the time from their regular responsibilities to carry out their board functions.

Besides the need for well-planned legislation to supply the necessary framework for a successful medicolegal investigation program, there are several other critical issues which must be addressed.

Lack of Public Understanding of Medicolegal Investigative Systems.

As with many, if not most, government services provided in municipalities throughout the country, there has been an increasing tendency to limit funding to expenditures of previous years, thus, by virture of inflation, curtailing their programs. To a large degree this has occurred to medicolegal agencies because they are not highly visible to the electorate

and frequently of little concern to the elected officials responsible for their support. Many of these community and government leaders believe that such agencies are concerned exclusively with the lower socioeconomic strata, or the ski row population of the community. They frequently do not take notice of reports which reveal that in their community, as in most, such a system plays a role in approximately 30 percent of all deaths therein, any one of which may be a member of their immediate family.

In the past, members of the forensic pathology community have tended to consider their responsibilities completed upon the conclusion of any single investigation, examination and its subsequent presentation in court. Only recently have community leaders come to realize that within these agencies, if reduced to a readily accessible form, is a vast array of information which may be used to identify and quantify community health problems, be they derived from undetected communicable disease, or related to occupational exposure. Even differences in the natural environment may be correlated with the incidence of a vast array of naturally occurring disease conditions and other demographic characteristics. Evaluation of such information may also be used to determine the efficacy of community and/or government programs in dealing with conditions proven to be hazardous or life-threatening.

Forensic pathologists have neither the personal time nor professional background to determine the cost effectiveness of their system although such a study might very well substantiate their suspicions that the apparent high cost of an outstanding medicolegal investigative system is modest compared with the cost of not having such a system. Likewise, any study to determine such a cost-benefit correlation, by virtue of the complexity

of the system must be carefully engineered and indeed quite sophisticated. Those involved in such a study would very quickly perceive that a substatantial percentage of the effort and cost of the system is spent not in the public interest concerning criminal litigation or community health hazards, but rather for a segment of the public which is in reality part of the private sector. Included here might be examinations conducted to gather evidence for a wide variety of wrongful death actions such as malpractice, product warranty, or motor vehicle fatalities. Because the results of such examinations have traditionally involved persons outside the immediate family, and because collectively the results of these examinations may play a role in subsequent regulatory procedures, they have been conducted pursuant to statute often without the knowledge of members of the immediate family who ultimately could benefit economically from litigation deriving from the use of the findings. As a consequence of this, the results of even the most sophisticated medicolegal investigations and examinations conducted, often with many acillarly procedures to substantiate the presence of noxious agents, are usually provided to any and all parties with a legitimate interest at little or not charge except perhaps for duplication and authentication of docuemnts. In effect then, these medicolegal investigative systems, supported almost exclusively by public funds, are spending a substatial portion of their time and resources in gathering information, which collectively is of greatest value to the public, while individually it may be of equal or greater value to a private party, namely the family of the deceased.

Change in the Nature and Volume of Workload.

Factors which appear to have increasingly precluded successful

recruiting into the practice of full-time forensic pathology include: the somewhat repetitive nature of the practice of forensic pathology, the oftentimes unaesthetic responsibilities deriving from investigation and examination of decomposed remains, and the interaction with those in the criminal and civil justice system which oftentimes causes inconvenience beyond the control of most of the attorneys and physicians involved. This inconvenience in and of itself, in this writer's experience, has served to alienate members of the full-time and part-time forensic pathology community who then discontinue practice. These limitations, combined with the physical and sometimes professional isolation of most medicolegal staff from the academic community, and a substantial difference in the remuneration afforded full-time forensic pathologists and their colleagues working in other settings, have increasingly hampered successful recruiting of a sufficient number of intellectually curious, highly motivated physicians even to replace those currently in full-time practices, much less make available quality practitioners for key positions in developing medicolegal investigative systems.

Salary Differentials between Public and Private Practitioners.

The salaries of most senior forensic pathologists in the nation today are in the range of $60,000 to $80,000, with perhaps a few slightly higher or augmented by benefits, such as health insurance, augmented retirement, and use of vehicles and communication devices. Graduates of approved training programs who become certified may expect remuneration approaching $100,000 to $125,000 per year within two to three years after association with a successful pathology practice. In addition, depending upon their senority within the group, members frequently now have retirement programs and provision for acquiring a substantial financial share

of the group assets, which may include investment programs.

At the present time there are 35 formal training programs in forensic pathology approved by the Accreditation Council for Graduate Medical Education. These programs collectively offer 64 position for training in forensic pathology. Review of the number of such positions actually filled in the past decade reveals a decreasing number of trainees in such programs, paticularly in the large northeastern programs which offers 47% of the positions, in spite of the increasing difficulty in locating graduates of approved residency programs in conventional anatomic or clinical pathology practice or one of the other subspecialties thereof. An informal survey conducted by Dr. Ronald Wright revealed that in 1981 there were trainees in only 31 of the available 64 training positions in the country and only 33 applicants for these positions in 1982. This is in spite of the fact that in many of the larger training programs the trainee holds a title and has responsibilities commensurate with that of a junior assistant medical examiner affording salaries in the range of $30,000 to $35,000. Tangible and intangible factors such as those detailed above including rate of remuneration, nature of practice, location in which the practice is carried out, interaction with other non-medical professions, including personal inconvenience deriving from such association, and the unaesthetic and routine nature of much of forensic pathology practice of forensic pathology less attractive to the modern day medical practitioner than prevailed twenty to thirty years ago.

Factors Affecting Patholgists' Income.

Recently there has been increasing concern over the level of remuneration to private practitioners of pathology by governmental agencies. This concern is focused on the subspecialty of clinical pathology and its routine laboratory examinations. Many of these tests have become mechanized, automated and computerized to such a degree that manual intervention is necessary only to collect the specimen, prepare it, maintain the instrumentation during its operation, and to introduce any reagents. In a hospital setting, these tests often result in a computer-generated report which is automatically totalled and updated on a daily basis for inclusion in the hospital chart. Such information is available at most nursing stations in modern hospitals by punching in the patient's identifying number or name. Similar instrumentation is available to perform volume anaysis of an equally large number of specimens collected in an outpatient community practice. Many of these procedures have become an indispensible part of routine admission and preoperative workup, the omission of which may serve as a basis for subsequent medicolegal interaction if there is any untoward event in the patient's hospitalization. The funds derived from charges for such procedures have in the past supported the anatomic studies of the hospital patholgist whose charged for the lengthy dissection and microscopic review entailed in some of the more complex surgical procedures has been modest in comparison with the time expended.

One of the major areas of the pathologist's endeavor and one which actually represents the culmination of his training and experience lies in the area of interphysician consultation, namely the suggestion of which examination or examinations should or might be conducted and thereafter the

interpretation of the results of such procedures in establishing diagnosis, prognostication or evaluation therapy. Government intervention has prompted the pathology community to examine their charges and the level of their personal involvement both in individual service as well as the management or direction of others engaged in pathology procedures. Ultimately such government intervention may serve to reduce the income of a sizeable portion of those engaged in the private practice of clinical pathology. This, coupled with the decreasing number of placement opportunities in anatomic and clinical pathology, may very well serve as a stimulus for some of these individuals to pursue their training in forensic pathology, thereby either making them more attractive in a private pathology group or enabling them to obtain a salaried position in the full-time practice of forensic pathology.

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TABLE 1

REPORTABLE CASES IN A
MODERN MEDICOLEGAL INVESTIGATIVE SYSTEM

A. Deaths which may be due entirely, or in part, to a factor other than natural disease. These include, but are not limited to:

1. Traumatic, chemical, or violent deaths, whether apparently homicidal, suicidal, accidental, or therapeutic, including but not limited to deaths due to mechanical, thermal, chemical, electrical or radiational injury, and maternal deaths due to abortion.
2. Sudden deaths not caused by readily recognizable disease.
3. Deaths under suspicious circumstances.
4. Deaths of inmates of public institutions not hospitalized therein primarily for organic diseases, and deaths of persons in custody of law enforcement officers.
5. All deaths that occur unexpectedly during, in association with, or as a result of diagnostic, therpeutic, surgical, and anesthetic procedures.
6. Deaths possibly related to, associated with, or as a result of the decedent's occupation.
7. Deaths unattended by a physician.
8. Deaths alleged to have been caused by an act of malpractice.
9. Any death suspected to be due to acute alcoholism, narcotics, or the effects of other drugs or toxic agents, including any death in which the diagnosis is suspected to be homologous serum jaundice, agranulocytosis, aplastic anemia, or any other possible complication of drug therapy or toxic exposure.

TABLE 1
(CONT)

10. Any death due to neglect.
11. Any stillbirth of 16 or more weeks' gestation unattended by a physician.
12. Deaths in nursing homes or other institutions without recent medical attention.
13. Deaths of all infants and children under 16 years of age, where medical history has not established some preexisting condition consistent with sudden death such as asthma, epilepsy, muscular dystrophy, etc.
14. Deaths which are possible directly or indirectly attributable to environmental exposure not otherwise specified.

B. Any deaths suspected to be due to infections or contagious disease wherein the diagnosis and extent of disease at the time are undermined.

TABLE 2

REASONS FOR PUBLIC INVESTIGATION AND THE
CONSEQUENCES OF FAILURE TO ACCOMPLISH THIS

Nature of Reported Cases	Reason for Investigation/ Examination	Consequences of No or Inadequate Investigation
1. Deaths resulting in criminal proceedings. a. Known or suspected homocide victim. b. Known or suspected victim of accidental death resulting from illegal act of another.	Determine, and document cause, circumstances, modality and instrumentality of death of identified victim for presentation at criminal proceedings where proof of these beyond a reasonable doubt is necessary. To determine extent, if any, that natural disease played a role in death.	Innocent may be falsely accused. Guilty either may not stand trial because murder or manslaughter victim not examined, or inadequately examined, hence: lengthy, costly trials with inappropriate conclusions, e.g., hung juries, requiring repeat trials whereas either stipulation or appropriate plea bargaining with good evidence may preclude or shorten trial.
2. Deaths in which civil litigation might be anticipated. a. Known or suspected accidental death.	To determine and document cause, circumstances, modality, and instrumentality of death of identified victim for settling of civil dispute, with reasonable medical certainty. To determine cause of and responsibility for incidents. To determine extent, if any, that natural disease played in death. Accidental death benefits may be awarded on report only without costly litigation.	Apparent accidental death may be considered natural; accidental death benefits would not accrue to survivors. Apparent natural death may be considered unnatural. Accidental death benefits may be awarded incorrectly.

TABLE 2
(CONT)

Nature of Reported Cases	Reason for Investigation/ Examination	Consequences of No or Inadequate Investigation
2. Deaths in which civil litigation might be anticipated. a. Known or suspected accidental death (continued).	Medical evidence gathered for civil litigation deriving from death, i.e. wrongful death, negligence, product warranty, mal-practice, etc., again, often affording settle-ment on report, without costly litigation.	
b. Known or suspected accidental death at work or of work related disease or condition, in-cluding those deriving or allegedly deriving from disease or injury during military service.	Same as in 2 above, except concerned with Workmen's Compensation and/or Veterans Admini-stration benefits.	
3. Known or suspected deaths from a community hazard.	Cause of accident or group of accidents identified, affording opportunity for corrective action to avoid further, similar accidents. Quantitation of risks of various types affords communities opportunity to address the greater problems first when resources are limited. To identify or sophisticate understanding of a hazard to a part of the community or the entire community which, upon recognition or understanding, may be corrected.	

TABLE 2
(CONT)

Nature of Reported Cases	Reason for Investigation/ Examination	Consequences of No or Inadequate Investigation
4. Other types of deaths	Sames as 2 above. To satisfy curiosity of survivors relative to incidence of familial related diseases. Also, to provide more accurate death statistics and therefrom identify trends in disease patterns, e.g., the decreasing incidence of atherosclerotic heart disease as cause of death. To provide basis for family grief counseling.	

LEGAL AND MEDICAL ABBREVIATIONS

Aggrav A and B	Agggravated assault and battery
A and B	Assault and battery
A2nd	Aortic 2nd sound
Ad lib	As much as desired
a.c.	Before meals
ACTH	Andrenocorticotrophic hormone
AFB	Acid-fast bacilli
A/G	Albumin-globulin ratio
$AgNO_3$	Silver nitrate
alk. phos.	Alkaline phosphatase
A.L.L.	Acute lymphocytic leukemia
A.M.L.	Acute myeloblastic leukemia
AMA	Against medical advice
AP	Anteroposterior
A & P	Auscultation and percussion
ASCVD	Arteriosclerotic cardiovascular disease
ASHD	Arteriosclerotic heart disease
AV	Atrial ventricular
Ba	Barium
B and E	Breaking and entering (burglary)
b.i.d.	Twice a day
BM	Bowel movement
BMR	Basal metabolic rate
BP	Blood pressure
BPH	Benign prostatic hypertrophy
BSP	Bromsulphalein
BUN	Blood urea nitrogen
BUS	Bartholin's, urethra, Skene's glands
C	Centigrade, cervical
CC	Chief complaint
CA	Carcinoma
Ca	Calcium
CBC	Complete blood count
cc	Cubic centimeter
ceph, floc.	Cephalin flocculation
CHF	Congestive heart failure
Cl	Chloride
C.L.L.	Chronic lymphocytic leukemia
cm	Centimeter
C.M.L.	Chronic myelocytic leukemia
CNS	Central nervous system
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CSF	Cerebrospinal fluid
Cu	Cubic, copper
CVA	Cerebrovascular accident
cva	Costovertebral angle

D & C	Dilation and curettage
DOA	Dead on arrival
DOE	Dyspnea on exertion
DT'S	Delirium tremens
DTR's	Deep tendon reflexes
DWI, DUI	Driving while under the influence of an intoxicating beverage or drug
ECG	Electrocardiogram
ECHO Virus	Enterocytopathogenic human orphan virus
ECU	Extended care unit
EDC	Expected date of confinement
EEG	Electroencephalogram
EENT	Eye, ear, nose and throat
EKG	Electrocardiogram
ENT	Ear, nose and throat
EOM	Extraocular movement
ER	Emergency room
EST	Erythrocyte sedimentation rate
ETOH	Alcohol
F	Farenheit
FBS	Fasting blood sugar
Fe	Iron
F.H.	Family history
Fx	Fracture
G.I.	Gastrointestinal
Gold Sol	Colloidal Gold Curve
gm	Gram
gr	Grain
G.U.	Genitourinary
Gyn	Gynecology
H	Hemophilus
h	Hour
Hbg	Hemoglobin
HCL	Hydrochloric acid
hct	Hermatocrit
HCVD	Hypertensive cardiovascular disease
HEENT	Head, eyes, ears, nose and throar
Hg	Mercury
HPF	High power field
h.s.	At bedtime
I-131	Radioactive iodine
I.C.U.	Intensive care unit
ICS	Intercostal space
I.I.	Icteric index
IM	Intramuscular
IPPB	Intermittent positive pressure breathing
I.Q.	Intelligence quotient
IUD	Intrauterine device
IV	Intravenous
IVP	Intravenous pyleogram

K	Potassium
KAU	King-Armstrong units
kg	Kilogram
K-W	Kimmelstiel-Wilson
L	Lumbar
LDH	Lactic acid dehyrodogenase
L.E.	Lupus erythematosis
LKS	Liver, kidneys, spleen
LLL	Left lower lobe
LLQ	Left lower quadrant
LMP	Last menstrual period
LOA	Leave of absence
LPF	Low power field
LP	Lumbar puncture
LSP	Left sternal border
LUL	Left upper lobe
LUQ	Left upper quadrant
Lymphs	Lymphocytes
M1st	Mitral 1st sound
M2nd	Mitral 2nd sound
mcg	Microgram
MCH	Mean corpuscular hemoglobin
MCHC	Mean corpuscular hemoglobin concentration
MCL	Midclavicular line
MCV	Mean corpuscular volume
mEq	Milliequivalent
mEq/L	Milliequivalent per liter
mg	Milligram
mm Hg	Millimters of mercury
M.I.	Myocardial infarct
ml	Milliliter
mm	Millimeter
mono	monocyte
MS	Multiple sclerosis
Na	Sodium
NG	Nasogastric
NP	Neuropsychiatry
NPN	Nonprotein nitrogen
NPO	Nothing by mouth
NSR	Normal sinus rhythm
Nurs	Nursery
O	Orally
O_2	Oxygen
OB	Obstetrics
OD	Right eye
OL	Left eye
OPD	Outpatient department
O.R.	Operating room

PA	Posteroanterior
P2	Pulmonic 2nd sound
P & A	Percussion and auscultation
PBI	Protein bound iodine
PCV	Packed cell volume
P.E.	Physical examination
Ped(s)	Pediatrid, pedioatrics
PEG	Pneumoencephalogram
PERRLA	Pupils equal, round, react to light and accommodation
pH	Acidity value
P.H.	Past history
P.I.	Present illness
PID	Pelvic inflammatory disease
PKU	Phenylketonuria
PMI	Point of maximal impulse
PMN's	Polymorphonucelar neutrophil leukocytes
PND	Paroxysmal nocturnal dyspnea, postnasal drip
p.o.	per os (by mouth)
polys	Polymorphonuclear neutrophil leukocytes
PP	Postprandial (after eating)
prn	As often as necessary
PSP	Phenosulfonphthalein test
PTT	Partial thromboplastin time
q.d.	Every day
q.h.	Every hour
q.i.d.	4 times a day
q.n.	Every night
q.n.s.	Quantity not sufficient
q.s.	Sufficient quantity
q2h	Every two hours
RBC	Red blood count, red blood cells
Resp	Respirations, respiratory
Rh	Rhesus
RHD	Rheumatic heart disease
RLL	Right lower lobe
RLQ	Right lower quadrant
RML	Right middle lobe
ROM	Range of motion
R/O	Rule out
RUL	Right upper lobe
RUQ	Right upper quadrant
SGOT	Serum glutamic exalacetic transaminase
S.H.	Social History
SOB	Shortness of breath
sp. gr.	Specific gravity
Stat	Immediately
Staph	Stphylococcus
Streph	Streptococcus

T	Temperature, thoracic
T & A	Tonsillectony and adenoidectomy
Tbc	Tuberculosis
t.i.d.	Three times a day
TIBC	Total iron binding capacity
TM	Tympanic membrane
TUR	Transurethral resection
TURP	Transurethral resection of prostate
URI	Upper respiratory infection
UTI	Urinary tract infection
VDRL	Veneral disease report (Venereal Disease Research Laboratory)
VPRC	Volume of packed red blood cells
Vit	Vitamin (followed by specific letter)
WNL	Within normal limits
WBC	White blood count, white blood cells
WD	Well-developed
WN	Well-nourished

APPENDIX A

Example of Modern Medicolegal Autopsy Report

POSTMORTEM REPORT

CENTER FOR FORENSIC AND ENVIRONMENTAL SCIENCE

UNIVERSITY OF NEW MEXICO
SCHOOL OF MEDICINE
Albuquerque, New Mexico 87131

ONI#

New Mexico State Penitentiary
Santa Fe, New Mexico
25 M Cau DOD: 2/3/80

IDENTIFYING WITNESS

NAME	ADDRESS	RELATIONSHIP
Albuquerque Police		

MEDICAL DATA OF DECEDENT

HEIGHT	WEIGHT	DATE AND HOUR OF POSTMORTEM EXAMINATION
6 FT. 0 INS.	158 LBS.	2/3/80 2130

After review of all reports and medical evidence, I conclude:

CAUSE OF DEATH
Enter only one cause per line for (a), (b), and (c).

*This does not mean the mode of dying, such as heart failure, asthenia, etc. It means the disease, injury, or complication which caused death.

MEDICAL CERTIFICATION

I. DISEASE OR CONDITION DIRECTLY LEADING TO DEATH* (a) Stab wound incisions, chest

ANTECEDENT CAUSES

DUE TO (b)

Morbid conditions, if any, giving rise to the above cause (a) stating the underlying cause last. DUE TO (c)

II. OTHER SIGNIFICANT CONDITIONS. Conditions contributing to the death but not related to the disease or condition causing death Craniocerebral injuries

Interval Between Onset and Death

DATE OF OPERATION	MAJOR FINDINGS OF OPERATION	AUTOPSY	IF YES, were findings considered in determining cause of death
		Yes [X] No [ ]	Y

ACCIDENT / SUICIDE / HOMICIDE (Specify)	PLACE OF INJURY (e.g., in or about home, farm, factory, street, office bldg., etc.)	(CITY OR TOWN) (COUNTY) (STATE)
HOMICIDE	Penitentiary	Santa Fe, Santa Fe, New Mexico

INJURY (Month) (Day) (Year) (Hour)	INJURY OCCURRED	HOW DID INJURY OCCUR?
2/2/80 UNK M.	While at Work [ ] Not While at Work [X]	Assaulted in prison riot

PATHOLOGIC DIAGNOSES

I. Incised stab wounds of right upper anterior thorax (2)
   A. Perforation of pleura between right ribs 2 and 3
   B. Perforation, upper lobe of right lung
   C. Right hemothorax (1120 ml.)
II. Incised stab wound to left upper anterior thorax
   A. Perforation of pleura between left ribs 5 and 6
   B. Graze wound to upper lobe of left lung
   C. Left hemothorax (40 ml.)
III. Incised stab wound to left lower anterior thorax
   A. Perforation of pleura between left ribs 11 and 12
   B. Perforation, left lateral diaphragm
   C. Graze wound, anterior fundus of stomach
   D. Perforation, jejunum and ileum
   E. Serosal hemorrhage, left descending colon
   F. Hemorrhage circumscribing left adrenal
   G. Hemoperitoneum (220 ml.)
IV. Incised stab wound to left lower anterior thorax
   A. Perforation, intercostal muscles along left 11th rib
   B. Perforation, left anterior diaphragm

COMMENTS The principle cause of this prisoner's death was the multiple incised stab wounds of his thorax and abdomen, resulting in external hemorrhage, indicating survival for several minutes. There are a total of 26 stab wounds. These are distributed as follows: 1 on neck, 16 on trunk, 8 on upper extremities, and 1 on the lower extremities. The incised wounds on the hands and arms (COMMENTS CONTINUED ON PAGE 3)

Death Certificate Completed by: .23 M.D. | Postmortem Examination by .37 M.D.

D. Multiple brain contusions
XVII. Blunt trauma to trunk
   A. Multiple abrasions and contusions
XVIII. Blunt trauma to extremities
   A. Multiple abrasions and contusions

COMMENTS, CONTINUED: most probably resulting from attempts to defend himself (defense wounds), indicating that he was conscious at the time he was assaulted by the perpetrator(s) using a knife or other instrumentality which was sharpened on one edge only. There are no significant blunt force injuries on the hands or arms suggesting very strongly that the victim was either in a position wherein he could not defend himself from these injuries principally to the head and neck, (such as lying down), or he was rendered unconscious by one of the first blows to the head. The injuries to the head were of a lesser magnitude than those suffered by some of the prisoners and may largely have resulted from kicking. Hemorrhage around both types of wounds indicates that the victim was alive when most of the injuries of both types were suffered. The absence of hemorrhage around a few of the knife wounds suggests the victim received these after death. Either the blunt trauma to the head or the incised wounds probably would have killed the victim independently, both must be considered to have played a role. Reasonably prompt medical intervention for either one or both of these types of injuries may well have saved this prisoner's life.

GENERAL EXTERNAL

The body is received in a white plastic-like opaque zippered container which is sealed with a white State of New Mexico, Office of the Medical Investigator label inscribed " , , (also known as), sealed by McFeeley, date 2/3/80". Written on the white opaque plastic-like container in black ink is "Moreno, 1350-280-1SF". The bag is held together with white strips of cotton-like apparent sheet material which is knotted around the leg portion of the body bag, the midportion, and the upper portion. These strips are partially stained with red-brown blood-like material. This well developed, well nourished Caucasian male appears to be between 22 and 30 years of age, weighs 158 pounds, and measures 72 inches in length. The body is clothed in the conventional manner, the right wrist is held in place over the right anterior waistband by the belt which is in place in the belt loops. The shoes and socks are on the feet and the shirt is partially buttoned in the middle and turned up over the upper chest. The underlying T-shirt is also folded and wrinkled and pulled up over the upper chest. On the left wrist is an orange plastic-like circular band which is inscribed "1350-280-1SF Moreno, Ben, (also known as)".

CLOTHING:

The body is clothed in the conventional manner and the clothing consists of:

1. Around the neck is a white and apparently brown patterned bandana which is tied with a knot. This loose fitting garment is totally soaked with red-brown blood-like material.
2. A dark blue long sleeve cotton-like shirt with blue plastic-like midline buttons and a collar. The shirt is damp and is diffusely stained with dry to damp red-brown blood-like matter anteriorly,

posteriorly, and over the sleeve areas. These red-brown blood-like stains cover approximately 70% of the total shirt surface. The right upper chest pocket is empty. The left upper chest pocket contains a nearly full package of Marlboro cigarettes which are soaked with apparent red-brown blood-like material.

A. On the left upper quadrant of the shirt is a 2.1 cm. x 0.1 cm. vertical slightly ragged perforation which has its midpoint 9.8 cm. to the left of midline and 12.6 cm. inferior to the anterior collar seam. This corresponds to the wound on the left lateral upper chest.

B. Commencing at the midportion of the medial border of the left upper pocket is an oblique ragged 1.8 cm. x 0.2 cm. perforation which extends from lateral and superior to medial and inferior. This perforation has its midpoint 9.8 cm. to the left of the midline and commences medially from the medial border of the left chest pocket. The perforation lies 22 cm. below the anterior collar seam.

C. Commencing 1.5 cm. below the midportion of the inferior border of the left pocket is a vertical ragged 2.2 cm. x 0.1 cm. perforation which has its midpoint 14.8 cm. to the left of the midline and 33 cm. inferior to the anterior collar seam.

D. On the right anterior midportion of the shirt is a transverse 2.1 cm. x 0.2 cm. ragged perforation which commences 3.1 cm. to the right of the midline and extends laterally. The lateral end of the perforation lies along the medial border of the right chest pocket. This perforation has its midpoint 22 cm. inferior to the anterior collar seam.

E. On the lower portion of the right chest pocket is a vertical 2.3 x 0.2 cm. ragged peforation which has its lower end 2.1 cm. superior to the inferior border of the midportion of the right pocket. This perforation has its midpoint 31 cm. inferior to the anterior collar seam.

F. On the superior posterior midportion of the right sleeve is an L-shaped ragged perforation which has the long arm of the L pointing superiorly and medially and the shorter arm pointing inferiorly and medially. The long arm measures to 4.3 cm. x 0.2 cm. while the short arm measures to 2.7 cm. x 2.7 cm. This perforation has its midpoint 28 cm. superior to the lower border of the right cuff.

G. On the inferior anterior surface of the right sleeve is a transverse irregular ragged 1.7 cm. x 0.3 cm. perforation which has its midpoint 15.7 cm. superior to the inferior cuff margin.

H. Along the right cuff button and button hole seam area is a transverse ragged 1.5 cm. x 0.2 cm. perforation which has its midpoint 18.5 cm. superior to the inferior right cuff margin.

I. On the right cuff with their midpoint respectively 4.2 cm. and 6.2 cm. from the midpoint of the right cuff button hole are two ragged perforations. The first of these lies transversely 1.1 cm. superior to the inferior right cuff margin and measures 1.8 x 0.2 cm. and this is the perforation closest to the button hole. The second perforation measures 2.2 cm. x 0.2 cm. and commences 3.9 cm. superior to the inferior right cuff margin and extends vertically superiorly.

J. On the anterior superior midportion of the left sleeve is a vertical 2.8 cm. x 0.2 cm. ragged perforation which has its midpoint 21 cm. inferior to the left sleeve seam.

K. On the lower anterior midportion of the left sleeve is a vertical 2.8 cm. x 0.2 cm. perforation which has its midpoint 20.5 cm. inferior to the left sleeve seam.

L. On the lower midportion of the left sleeve is a third ragged

A pair of white cotton-like boxer undershorts which have yellow and blue fleur-de-lis and coat of arm emblem patterns over the surfaces. The undershorts are damp and diffusely stained with faint red-brown blood-like stains. On the posterior inner waistband surface is a white label inscribed in part, "50% Combed Cotton, 32". Also inscribed in apparent blue ink on the posterior inner waistband is "27192". This inscription is barely legible and the numbers are difficult to make out.

7. A pair of light blue cotton-like socks which are totally soaked with water-like material. Red-brown blood-like stains extend over the heel and plantar surfaces in a faint scattered fashion.
8. A pair of apparent black leather-like ankle length work boots with six eyelets through which are laced black cloth laces. No inscriptions or labels are noted inside the shoes. The soles and heels are symmetrically worn and the shoes are totally soaked with water-like material. Notches on the anterior surface of the heels measure to 1.1 cm. in width and 0.6 cm. in depth.
9. Submitted separately in the white plastic-like zippered container is a 24 3/4 inch in length by 3/4 inches in diameter brown to black metal pipe which weighs approximately two pounds.

EXTERNAL EXAMINATION

The body is cold to the touch, rigor mortis is complete, and livor mortis is not evident on the body. The head is normocephalic and the scalp is covered with brown hair which measures to 7.1 cm. in length. The irides are brown, the pupils are 0.4 cm. in diameter, round and equal, and the sclerae are white. The nose, ears, and lips have a normal structure and appearance. The upper lip is covered with a brown mustache which measures to 1.1 cm. in length and extends to the angles of the mouth. The teeth are in a state of good repair and the tongue is in the midline. The trachea is in the midline with no palpable tracheal masses. The thorax is symmetrical. The abdomen is flat with no palpable abdominal masses. The external genitalia and pubic hair pattern are those of a normal adult circumcised male. The testes are in the scrotal sac. The upper and lower extremities have a normal structure and appearance. The feet along the plantar surfaces have a somewhat "washer woman" appearance which extends to the plantar surfaces of the toes. This "washer woman" appearance is not evident on the hands or fingers. The anus is patent and measures to 1.5 cm. in diameter. The back is unremarkable.

IDENTIFYING MARKS AND SCARS

1. On the anterior midline lower chin is a faint 1.2 cm. x 0.5 cm. vertical amateur-like tattoo which is indecipherable.
2. On the midline upper chest commencing at the level of the medial clavicles and extending inferiorly is a blue amateur-like 16.5 cm. vertically by 18.4 cm. transversely tattoo which depicts a Christ-like head with an apparent crown of thorns and above this to the right and left are two apparent angels.
3. On the anterior abdomen is a vertical 26.0 cm. x 0.8 cm. white well healed apparent surgical scar which extends from an area 2.5 cm. inferior to the xiphoid process to the region of the symphysis pubis. This scar lies 2.6 cm. to the left of the midpoint of the umbilicus. Along the scar are multiple oblique possible suture scars which extend from inferior and lateral to superior and medial and measure to 2.5 cm. by less than 0.1 cm. each.

C. Commencing at the right antecubital fossa and extending vertically inferiorly is an elliptical 4.8 x 0.5 cm. white apparent needle track which is partially covered by the hair of the woman's head tattoo previously described (#7). This apparent track is excised and saved.

EVIDENCE OF INJURY

The head and neck are diffusely covered with multidirectional, nonpatterned dried to damp red-brown blood-like material which extends over the face, neck, and into the hairline. The upper body, including the thorax and upper extremities are also partially covered with red-brown blood-like material.

HEAD AND NECK:

1. Commencing 4.6 cm. superior to the midportion of the right eyebrow and extending posteriorly and laterally is a 4.8 cm. x 0.3 cm. laceration which is partially circumscribed along the anterior borders by an area of red-brown superficial denudation which extends 0.3 cm. from the wound margins. Adjacent to the anterior border is a round to oval partially confluent 0.5 cm. in greatest dimension red-brown superficial denudation. This laceration extends to the fascia overlying the skull but no skull defect is evident.
2. Commencing at the medial border of the left eyebrow and extending in slightly zig-zag fashion superiorly is a 7.2 cm. x 0.3 cm. laceration which extends to the fascia overlying the skull. The superior border of the wound is partially circumscribed by red-brown superficial denudation which extends to 0.2 cm. from the margins of the laceration. Commencing at the inferior border of this zig-zag wound and extending obliquely superiorly and laterally is a 2.7 cm. x 0.3 cm. oblique laceration which extends to the fascia of the skull.
3. Commencing 4.2 cm. superior to the lateral border of the left eyebrow is a vertical 3.9 cm. x 0.4 cm. laceration which extends superiorly and posteriorly. The borders of this laceration are partially circumscribed by red-brown superficial denudation which extends to 0.2 cm. from the wound margins. The laceration extends to the fascia overlying the skull and no defects are noted in the skull.
4. Commencing 0.5 cm. inferior to the glabella and extending over the right side of the bridge of the nose is a somewhat linear 2.1 cm. x 0.3 cm. red-brown superficial denudation.
5. Commencing at the lateral border of the right eye and extending laterally and slightly inferiorly is a transverse to slightly oblique 1.3 cm. x 0.2 cm. laceration which is partially circumscribed along the lateral and superior borders by an area of red-brown superficial denudation which extends to 0.3 cm. from the wound margins.
6. On the upper portion of the right cheek commencing 2.1 cm. inferior to the lateral border of the right eye and extending medially and inferiorly is an oblique 2.2 cm. x 0.4 cm. laceration.
7. The left upper eyelid is covered by a red-purple to slightly blue superficial discoloration which measures to 4.8 x 1.8 cm. The lid appears to be slightly swollen compared with the right side.
8. On the midportion of the left cheek with its midpoint 4.2 cm. to the left of and 1.7 cm. superior to the lateral border of the mouth is a 0.6 x 0.5 cm. vertical red-brown superficial denudation.
9. On the midline of the chin, extending to the right and slightly

which has its midpoint 57 1/2 inches above the left heel with the body erect and the arms at the sides, 25 inches above the left gluteal fold with the body seated, 11.7 cm. to the left of the midline, and 6.2 cm. inferior to the midpoint of the left clavicle. The superior border of the wound is somewhat squared off and blunted while the inferior border of the wound is sharply pointed. The wound track extends from superior to slightly inferior and from right to slightly left.

A. A perforation of the subcutaneous muscle tissue has similar dimensions to that of the skin wound and is circumscribed by hemorrhage extending to 1.8 cm. from the wound margins.
B. A perforation of the intercostal muscles between left ribs 5 and 6 measures to 2.5 cm. x 1.2 cm. and is circumscribed by hemorrhage extending to 0.9 cm. from the wound margins. The pleura overlying this region is perforated by a defect of similar dimensions which lies along the left lateral thorax.
C. On the lower lateral border of the upper lobe of the left lung is a 1.4 cm. x 0.3 cm. grazing wound which is partially circumscribed by hemorrhage which extends to 0.1 cm. from the wound margins. The left pleural cavity contains 40 ml. of liquid blood.

4. Over the left lower anterior to lateral thorax are two vertical incised stab wounds which have their average midpoint 45 inches above the left heel with the body erect and the arms at the sides and 12 1/2 inches above the left gluteal fold with the body seated. The most medial of these wounds is vertical, measures to 2.4 x 0.2 cm. and has a blunted squared off superior end and a slightly pointed inferior end. The midpoint of this wound is 11.2 cm. to the left of the midline and 18.6 cm. inferior to the midpoint of the left nipple. The wound track extends from left to right and essentially horizontally.
   A. A perforation of the muscle and subcutaneous tissue has similar dimensions as that of the skin wound track and is circumscribed by hemorrhage extending to 2.7 cm. from the wound margins.
   B. A perforation of the intercostal muscles along the 11th rib as well and the defect is circumscribed by hemorrhage extending to 0.5 cm. from the wound margins.
   C. A perforation of the left anterior diaphragm mesures to 1.5 cm. in greatest dimension and is circumscribed by hemorrhage extending to 1.6 cm. from the wound margins.
   D. A vertical partial penetration of the left side of the left side of the first lumbar vertebra measures 0.9 cm. x 0.1 cm.
5. Commencing 1.5 cm. lateral to the latter wound is a similar incised stab wound which commences at the level of the midpoint of the 1st stab wound and extends inferiorly. This wound measures 2.8 x 0.2 cm. and has a squared off blunted superior margin and a sharply pointed slightly stellate inferior end. This wound extends from superior to inferior and left to slightly right.
   A. A perforation of the subcutaneous and muscular tissue has similar dimensions as that of the skin wound and is circumscribed by hemorrhage extending to 0.5 cm. from the wound margins.
   B. A perforation of the intercostal muscles between lateral left ribs 11 and 12 measures to 1.9 cm. in greatest dimension and is circumscribed by hemorrhage extending to 0.5 cm. from the wound margins. A similar defect is evident in the pleura and the adjacent left lateral diaphragm.
   C. A grazing wound of the anterior surface of the fundus of

index finger is a 2.8 x 0.2 cm. incised wound. The ends of this wound are ill defined and somewhat ragged.

13. Extending from the midportion of the extensor surface of the right forearm to the lower extensor surface of the right forearm are five irregular motled red-brown superficial denudations which measure from 0.6 x 0.5 cm. to 2.6 x 0.7 cm.
14. On the superior anterior right upper arm is a mottled red-purple 7.5 x 4.8 cm. vertical somewhat oval superficial discoloration.
15. On the superior left shoulder is a transverse 2.2 x 1.1 cm. red-brown superficial denudation.
16. On the anterior to lateral midportion of the left upper arm is a linear 1.0 x 0.1 cm. vertical red-brown superficial denudation which has an irregular somewhat oval to slightly triangular transverse 0.6 x 0.3 cm. red-brown superficial denudation confluent with the linear one previously described.
17. On the midportion of the medial surface of the left upper arm is a transverse 5.8 x 0.2 cm. red-brown superficial denudation.

EXTREMITIES - LEGS:

1. On the lateral to posterior surface of the left thigh commencing 10.0 cm. superior to the left popliteal fossa and extending from inferior and posterior to superior and anterior is an oblique 4.6 cm. x 0.3 cm. incised stab wound which has two sharply pointed ends. The wound extends into the subcutaneous tissue and muscle and is circumscribed by hemorrhage extending to 0.5 cm. from the wound margin.
2. Along the posterior lower portion of the left thigh is a transverse mottled 5.3 cm. x 0.6 cm. red-brown superficial denudation.
3. On the lateral upper portion of the left lower leg are two red-brown superficial denudations which measure to 0.6 cm. x 0.5 cm.
4. On the lower anterior left knee is a triangular 1.6 cm. x 0.6 cm. transverse red-brown superficial denudation.
5. Circumscribing the superior, inferior, and lateral portions of the left knee are red-purple superficial discolorations which measure to 8.7 cm. x 4.3 cm.
6. On the anterior midportion of the left lower leg extending to the anterior ankle are two red-purple superficial discolorations which measure to 1.7 cm. x 1.5 cm.
7. Commencing 15.2 cm. superior to the midpoint of the right knee along the medial surface of the right thigh is an oblique incised wound which extends from posterior and inferior to superior and anterior and measures to 5.2 cm. x 0.5 cm. This wound extends into the subcutaneous fat. Extending from the superior end of this wound is an oblique extension of the wound which is represented by a 2.3 cm. x 0.4 cm. superficial red-brown incised wound. The main portion of the incised wound has sharply pointed ends both inferiorly and superiorly.
8. Extending from the anterior to medial midportion of the right thigh to the anterior right ankle are more than 15 irregular to round to oval red-purple superficial discolorations which measure to 4.8 cm. x 2.2 cm.
9. Along the medial lower right knee are two red-brown superficial denudations which measure to 2.1 cm. x 0.4 cm.
10. Extending along the superior anterior portion to the midportion of the anterior right lower leg are four irregular red-brown superficial denudations which measure to 4.2 cm. x 8.0 cm. In this same area are

three irregular lacerations which measure 0.4 cm. x 0.4 cm.

EVIDENCE OF THERAPY

None.

INTERNAL EXAMINATION

The subcutaneous fat over the thorax measures to 0.5 cm. in thickness, and over the abdomen to 1.4 cm. in thickness. The right pleural cavity contains 1120 ml. of liquid blood. The left pleural cavity contains 40 ml. of liquid blood. The peritoneal cavity contains 220 ml. of liquid blood. The pericardial sac contains 20 ml. of yellow clear fluid.

CARDIOVASCULAR SYSTEM: The pericardial surfaces are smooth, glistening, and unremarkable; the pericardial sac is free of significant fluid or adhesions. The coronary arteries arise normally, follow the usual distribution, are widely patent, and are without evidence of significant atherosclerosis or thrombosis. The chambers and valves bear the usual size-position relationship and are unremarkable. The myocardium is dark red-brown, firm, and unremarkable; the atrial and ventricular septa are intact. The aorta and its major branches arise normally, follow the usual course, and are widely patent and free of significant atherosclerosis and other abnormality. The vena cava and its major tributaries return to the heart in the usual distribution and are free of thrombi.

RESPIRATORY SYSTEM: The hypopharynx, larynx, trachea, and bronchi are normally developed and patent. The mucosal surface is covered by a thin film of liquid blood in the superior trachea and larynx. The pleural surfaces are smooth, glistening, and unremarkable bilaterally except as otherwise noted. Except as noted, the pulmonary parenchyma is yellow-tan, dry, and fluffy anteriorly and superiorly and gradually becomes dark red-purple posteriorly, and in the lower lobes, exudes slight to moderate amounts of blood and frothy tan fluid; no focal lesions are noted. The pulmonary arteries are normally developed, patent, and without thrombus or embolus.

RETICULOENDOTHELIAL SYSTEM: The spleen has a smooth, intact capsule covering red-brown, moderately firm parenchyma; the lymphoid follicles are unremarkable and measure to 0.3 cm. in diameter. The regional lymph nodes are unremarkable; the mesenteric nodes are soft, red-brown to yellow-tan, and measure to 0.9 x 0.7 x 0.7 cm. The bone marrow is red-purple, homogeneous, and without evidence of focal abnormality.

LIVER AND BILIARY TRACT: The hepatic capsule is smooth, glistening, and intact covering dark red-brown, moderately congested parenchyma with no focal lesions noted. The gallbladder contains 10 ml. of yellow-green-brown, slightly mucoid bile; the mucosa is velvety and unremarkable. The extrahepatic biliary tree is patent and without evidence of calculi.

ALIMENTARY TRACT: The esophagus is lined by gray-white, smooth mucosa. The gastric mucosa is arranged in the usual rugal folds, and the lumen contains 30 ml. of greenish-brown mucoid particulate material. Except as noted, the small bowel is of a normal caliber throughout with tan, delicately folded mucosa and contains yellow-brown, liquid feces. The appendix and cecum are unremarkable. Except as noted, the large bowel

POSTMORTEM REPORT	CENTER FOR FORENSIC AND ENVIRONMENTAL SCIENCE	CASE NO.	PAGE 20

pocket, 11) Trace evidence - itemized on envelope, 12) Hair, axilla; 13) Hair, pubic area; 14) Hair, scalp; 15) Weapon from upper right arm, 16) Fingernail clippings, both hands.

WITNESSES:
, Morphology Technician Supervisor
, Morphology Technician

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3/25/80

POSTMORTEM REPORT	STATE OF NEW MEXICO OFFICE OF THE MEDICAL INVESTIGATOR	CASE NO.	PAGE 1

MICROSCOPIC NOTES

TISSUE EXAMINED:

Heart:	x	Uterus:		Spinal Cord:	
Aorta:		Ovary:		Thymus:	
Lungs:	xxxx	Thyroid:	x	Seminal Vesicles:	
Spleen:	xx	Parathyroid:		Breast:	
Liver:	x	Esophagus:		Gallbladder:	
Pancreas:	xx	Stomach:		Skin:	xxxx
Adrenals:	xx	Small Intestine:		Muscle:	
Kidney:	xx	Large Intestine:		Bone Marrow:	
Bladder:		Lymph Nodes:		vertebral	
Prostate:	x	Pituitary:		femoral	
Testes:		Brain:	xxxx	costal	
				sternal	
				Other:	Anal: x
					Right antecubital fossa: x

MICROSCOPIC DESCRIPTION:

LUNGS: Sections of the lungs reveal marked focal intraalveolar blood.

BRAIN: Sections of brain reveal cortical areas of perivascular hemorrhage. In the pons is an occasional scattered perivascular hemorrhage.

RIGHT ANTECUBITAL FOSSA: Sections of right antecubital fossa skin reveal pigment in the dermis as well as minimal fibrosis. No foreign body granulomas are evident.

ADRENAL: A section of adrenal reveals intraadipose hemorrhage adjacent to the adrenal.

ANUS: An anal section is unremarkable.

OTHER SECTIONS: Other sections are unremarkable.

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3/30/80

APPENDIX B

Examples of Investigative and Examination Guidelines

INVESTIGATION GUIDELINES
PERI-OPERATIVE AND THERAPEUTIC

CASE NUMBER _____

CALL TO THIS OFFICE:

Time: __ : __ Date: __/__/__

By: _____

Agency: _____

SUBJECT: _____

Address: _____

Age: _____ Sex: _____ Race: _____

Marital Status: _____

PRONOUNCED DEAD:

By: _____ Date: __/__/__ Time: __ : __

Where: _____

Police Agency: _____

Officers involved: _____

Found: Time: __ : __ Date: __/__/__

By: _____

Any relationship to deceased? _____

Procedure done? _____

_____

Usual risk involved with this procedure? Minimal _____ Moderate _____ High _____

Heroic _____ Reported by _____

Was permission given prior to the procedure? No _____ Yes _____ By whom _____

Relationship to the deceased _____

Was the procedure and risk fully explained prior to obtaining permission? No _____

Yes _____ Who explained it? _____

Length of time the deceased was known to have had the disease or injury prior to the procedure to correct it _____. Did the deceased put the procedure off until the prospective survival decreased? No _____ Yes _____

Explain _____

_____

Did the deceased have other diagnosed diseases or injuries that were not considered to be an additional risk to this procedure? No _____ Yes _____ Explain _____

_____

Did the deceased have other diagnosed diseases or injuries that would have knowingly increased the risk of this procedure? No _____ Yes _____ Explain _____

_____

Did the deceased understand the increased risk due to the additional diagnoses? __

No _____ Yes _____ Explain _____

_____

Was the deceased being treated for these other diseases or injuries? No _____

Yes _____ Explain _____

_____

Were additional diseases or injuries found during the procedure that were previously undiagnosed? No _____ Yes _____ Explain _____

_____

Had these diseases or injuries been known, would the procedure have been done anyway? No _____ Yes _____ Explain _____

If additional disease or injuries were found during the procedure, did this discovery negate or change the originally planned procedure? No _____ Yes _____ Explain _____

Had these undiagnosed diseases or injuries been known prior to the procedure, would the procedure have been attempted anyway? No _____ Yes _____ Explain _____

Was this admission scheduled _____ or an emergency? _____

Were all of the routinely ordered pre-operative laboratory tests done? No___ Yes _____ Explain _____

Were the results available to the surgical team prior to the procedure? No _____ Yes _____ Explain _____

Were they reviewed by the surgical team? No _____ Yes _____ Explain _____

Were they normal for the deceased? No _____ Yes _____ Explain _____

Was blood typed and cross matched prior to the procedure? No _____ Yes _____

Was the blood ordered for this procedure the amount normally ordered for similar types of surgery? No _____ Yes _____ Explain _____

Did the deceased have any known allergies to any medication? No _____ Yes _____ Explain _____

If any known allergies, were any of them to drugs that would normally be used in this procedure? No _____ Yes _____ Explain _____

Were any of the drugs with a known allergy used? No _____ Yes _____ Explain _____

Were pre-anesthetic agents used for this procedure? No _____ Yes _____

Explain _____

(If pre-anesthetic agents were used complete the following)

1. Agent used _____ Amount used _____ Method of administering _____ Time administered _____ Administered by _____ Any untoward reaction at the time of administration? No _____ Yes _____ Explain _____

2. Agent used _____ Amount used _____ Method of administering _____ Time administered _____ Administered by _____ Any untoward reaction at the time of administration? No _____ Yes _____ Explain _____

3. Agent used _____ Amount used _____ Method of administering _____ Time administered _____ Administered by _____ Any untoward reaction at the time of administration? No _____ Yes _____ Explain _____

Are all of these agents normally used for this procedure? Yes _____ No _____

Explain _____

Who ordered these agents? _____ When? _____

Does the person who administered the agents on this case normally administer pre-anesthetic agents? Yes _____ No _____ Explain _____

Anesthesia:

A. What anesthesia was used? 1. _____, 2. _____, 3. _____

Why was (were) this agent(s) selected? _____

What was the total dose of each? Inhalation _____ (duration of administration and gas mixture, including inductive agents); Spinal _____

(agent, diluent, injection site); Parenteral _____

_____

(agent, total dose, drip flow, exact length of administration, and diluent). Was muscle relaxant used? _____

_____

(agent, method of administration, total dose, observed effects, including respiratory.)

When was the anesthesia started? _____ by _____

Any untoward reaction when the anesthesia was administered? No _____

Yes _____ Explain _____

_____

Is the time period between the pre-anesthesia agent and the administration of the anesthesia normal? Yes _____ No _____ Explain _____

_____

If there was an unusual time delay, why? _____

_____

B. Was any other anesthetic agent administered in the 48 hours prior to this procedure? Detail _____

_____

(Total dose of all agents, time and date)

Operative or therapeutic procedure:

At what time was the procedure started? _____. Was the subject stable at that time? Yes _____ No _____ Explain _____

_____

Was the time delay between the start of the anesthesia and the start of the procedure normal? Yes _____ No _____ Explain _____

_____

Was the subject satisfactorily anesthetized for the procedure? Yes _____

No _____ Explain _____

_____

What is the usual duration of this procedure? _____

How long did this particular procedure take? _____. If different from the usual time, explain why _____

_____

At the time the procedure was started were all of the fluid infusions running properly? Yes _____ No _____ Explain _____

_____

Did any of the fluid infusions or transfusions develop problems during the procedure? No _____ Yes _____ Explain _____

_____

If there were fluid infusions or transfusions used during the procedure, list them with total quantity administered (ml.) and the rate of flow. 1) _____ _____, 2) _____, 3) _____, 4) _____ _____, 5) _____ 6) _____.

Were there additives to the infusions? List them and total amount of each added and administered: 1) _____, 2) _____, 3) _____.

Was there an excessive amount of hemorrhage with this procedure? No _____

Yes _____ Explain _____

_____

At any time during the critical portion of the procedure were there any unplanned delays? No _____ Yes _____ Explain _____

_____

At any other time during the procedure was there a delay? No _____ Yes _____

Explain _____

_____

Were there any unplanned changes in the critical portion of the procedure?

No _____ Yes _____ Explain _____

_____

Were there any unplanned changes during any other part of the procedure?

No _____ Yes _____ Explain _____

_____

Were there any untoward or unexpected events during the procedure? No _____

Yes _____ Explain _____

_____

If there were any untoward or unexpected events, explain what was done to correct them or what additional procedures were initiated as a result, including heroic attempts at resuscitation. (If respiratory or cardiac arrest-duration) _____

_____

_____

What time was the procedure terminated? _____

Did the subject leave the operating room in a stable condition? Yes _____

No _____ Explain _____

_____

List all persons present in the operating room and their duties.

1) _____, _____ 2) _____, _____

3) _____, _____ 4) _____, _____

5) _____, _____ 6) _____, _____

7) _____, _____ 8) _____, _____

9) _____, _____ 10) _____, _____

Did the subject arrive at the recovery room in a stable condition? Yes _____

No _____ Explain _____

_____

Were any additional procedures performed on the subject while in recovery?

No _____ Yes _____ Explain _____

_____

Explain the terminal events. _____

_____

_____

_____

What resuscitative or heroic procedures were performed during the terminal episode? _____

_____

Anything else unusual about this case? No _____ Yes _____ Explain _____

_____

_____

INVESTIGATOR _____

PROCEDURE	INTL. UPON COMPLETION
Examine exterior of body, clad, as received. *Look for any signs of cause and manner of death.*	_____
Photograph overall body as received. *These photographs will aid in the documentation of the chain of evidence and serve to refresh the memory of the investigator and examiner. They may also reveal features not noted previously to support another hypothesis for the time.*	_____
Search for and remove special items of evidence. (Individually package and label.) *Trace evidence may provide clues to identify the assailant and/or to help in or rule out suspects. It may also be used to locate the scene of the crime or the location of the body after the crime.*	_____
Undress body carefully over plastic bag and air dry clothing. Seal droppings with trace evidence. *Same as immediately above.*	_____
X-ray entire body. If necessary call X-ray technician. *The radiologist is invaluable in aging bony injuries and has a large repertoire of bone and soft tissue injury described within the radiology literature, associated with specific patterns of abuse.*	_____
Examine exterior of body unclad, as received. *Look for evidence of violence.*	_____
Note and record degree, color, and distribution of livor mortis when initially examining body prior to autopsy. *It is important to know the appearance of the body at the scene to determine if rigor and livor are appropriate for position of the body.*	_____

If case appears to be sex related, remove for microscopic and/or serologic examination as follows:

1. Swab of oral cavity--smear on two glass slides, fix (with spray) and then place in sealed, labelled screw-top tube.
2. Swab of rectal cavity--prepare as in #1 above.

In addition, dab liquid material and drop of blood onto center of four inch squares of clean, new paper

PROCEDURE — INTL. UPON COMPLETION

towel or filter paper, outline with pencil, air dry, package, and label.

Sperm can be identified microscopically with the aid of special stains. Acid phosphatase and other enzyme determinations can be made on the swabs. The tubes and dabs must be sealed and labelled to insure the chain of evidence. Dabs can be examined for acid phosphatase or used for serological techniques.

Saliva dabs can be analyzed for secretor groups. In case of spurious results, the remainder of the vaginal contents can be evaluated as above. The dabs are of particular value in the event liquid specimens putrefy inadvertently during transmission or storage.

Describe clothing indicating general nature, defects due to violence of any type, their location, size (in centimeters), and approximate location (in inches from landmarks).

Clothing defects may provide valuable clues about the cause and manner of death, as well as the events leading to death.

Photograph external unusual features of body as received with body landmarks and identifying number in photograph.

These photographs will aid in the documentation of the chain of evidence and serve to refresh the memory of the investigator and examiner. They may also reveal features not noted previously to support another hypothesis for the time.

Remove control samples from body for trace evidence. Individually package as indicated. Seal and label:

1. Hair from head
2. Hair from axilla
3. Hair from pubis
4. Clippings of nails, left hand
5. Clippings of nails, right hand.

Samples of the victim's hair are necessary for comparison with any hairs found on the clothing or at the scene. If the victim attempted defense, fragments of skin, blood or other trace evidence from the assailant might be under the fingernails.

Wash body down carefully, insuring that significant external findings are not removed.

Subtle evidence of injury may be seen after the body is

PROCEDURE — INTL. UPON COMPLETION

washed, especially if the skin is dirty. Vigorous cleansing should be avoided so as not to disturb delicate evidence of injury, i.e., gunpowder flakes, etc.

Examine exterior of body after cleansing.

The removal of dirt, drainage, and debris may afford better visualization of external injury. The time delay associated with these procedures may allow the development of dependent lividity, thereby affording better delineation of anterior poorly delineated bruises.

Describe natural external features of body.

This procedure is a normal part of the medicolegal autopsy and is vital for victim identification.

Describe in detail the identifying marks, scars, tattoos, etc., noting exact location, size, content, etc. Note whether tattoo is professional or nonprofessional in appearance.

In unidentified remains, more detailed information concerning marks, scars, and tattoos may later assist in establishing identity from verbal descriptions and photographs.

Describe unnatural external features of body (external evidence of injury):

1. Size, shape, color, location (either by body landmarks or above heel or buttocks)
2. Group collections of similar or contiguous injuries
3. Note relationship of contiguous injuries to each other if significant. Measure intervals on center.

This portion of the examination is paramount to a medicolegal autopsy and accurate, well performed, factual, yet concise descriptions are priceless. Precise location of wounds in certain instances is invaluable in reconstruction of body, assailant, and scene relationships.

Trace pattern injuries on flexible transparent mylar. Identify body landmarks on tracing.

Such tracings allow superposition on a suspected weapon or even plaster casts of hands.

Photograph face of body from front with identification number in the photograph.

This photograph will establish identity in court.

PROCEDURE	INTL. UPON COMPLETION
Photograph unusual identifying features of body (tattoos, scars, etc.) with identifying number and landmarks in photograph. *If the identification is questioned, documentation of unusual features will aid in positive identification.*	_____
Photograph all external unusual features of body after cleansing with body landmarks, identifying number, ruler, and if necessary, color chart in photograph. *These photographs document the descriptive report.*	_____
Conduct dissection. *Internal evidence of injury should not be obscured by careless organ removal. The organs should be viewed in situ and traumatic findings ascertained.*	_____
Collect appropriate samples for toxicology: 1. Blood 2. Urine 3. Vitreous *Blood should be collected from the heart and a large, more peripheral artery or vein and accordingly labelled. Urine should be collected in such a way as not to contaminate the sample with blood. Vitreous humor is technically more difficult to evaluate toxicologically, but usually represents a more reliable sample in massive internal trauma cases.*	_____
Collect samples for serology: 1. Blood *Blood grouping of the victim's blood is vital information for comparison with blood stains found on the assailant or at the scene.*	_____
Describe in situ internal evidence of injury, in detail, then therapy (if present). *Descriptions must be thorough, accurate, and concise. Logically ordered descriptions are preferable.*	_____
Photograph internal evidence of injury or therapy, in situ, if present. *These photographs document the descriptive report.*	_____
Describe internal evidence of injury, then therapy (if present) after dissection of organs. *Descriptions must be thorough, accurate, and concise. Logically ordered descriptions are preferable.*	_____

PROCEDURE	INTL. UPON COMPLETION
Photograph internal evidence of injury or therapy on organs, dissected, if present. *These photographs document the descriptive report.*	_____
Describe internal natural findings. *Natural disease should not escape the eye of the forensic pathologist since natural disease may often play a role in traumatic death.*	_____
Collect representative sections of unusual pathological findings from appropriate organs and samples of all organs for histopathologic examination. *This procedure is self-explanatory, is the standard procedure for all well conducted autopsies and is not unique to a forensic autopsy.*	_____
Remove sections of various color and type of wounds, label and button individually, i.e., bruises, etc. *Histological evaluation of wounds should not be disregarded. This information may provide important "event-time" relationships.*	_____
Retain appropriate gross organs as necessary for illustration to attending physician or as subsequent evidence in criminal or civil proceedings.	_____
Photograph significant findings on dried clothing with identifying number and ruler in photograph. Individually package significant portions, seal, and label. *Individual packaging will insure against cross-contamination with other articles of clothing and will aid in chain of evidence.*	_____
Bag all clothing including individually packaged. *Bagging aids in preservation of the chain of evidence and helps avoid contamination of clothing.*	_____
Complete appropriate portions of organ weight form. *Organ weights may be easily overlooked but provide information about certain pathological processes and should be included as part of every autopsy report.*	_____
Complete description of findings and conclusions concerning cause and manner of death on "Report of Death" form.	_____

CONTINUED

2 OF 5

PROCEDURE	INTL. UPON COMPLETION
The final report should be completed promptly after all pertinent examinations are finished. The rough drafts should be reviewed with the photographs. The smooth copy should be carefully reviewed to avoid typographical errors and errors of omission.	
Complete body transfer and delivery receipt (body evidence receipt). *Body transfer records must be kept to legally substantiate proper body handling and body chain of custody.*	_____
Complete toxicology request form. *This form serves as the request for toxicological examination. When the laboratory is afforded clues concerning the nature and quantity of toxic agents, results are infinitely more satisfactory, and more readily obtainable.*	_____
Submit collected specimens to Forensic Physical Science Laboratory, obtain receipt. *Such receipts are necessary in maintaining the proper chain of evidence.*	_____

GLOSSARY OF LEGAL TERMS

Arraignment	In criminal practice, to bring a prisoner to the bar of the court to answer the matter charged upon him in the indictment. The arraignment consists of calling upon the prisoner by name, and reading to him the indictment (in English) and demanding of him whether he be guilty or not guilty, and entering his plea.
Attorney	In the most general sense, this term denotes an agent or substitute employed by a party, or one who is appointed and authorized to act in the place of another. When used with reference to proceedings of courts, the term always means "attorney-at-law," unless a contrary meaning is clearly indicated. "Lawyer" and "attorney" are synonymous.
Attorney-At-Law	An advocate, counsel, or official agent employed in preparing, managing, and trying cases in the courts. In the U. S. attorney-at-law usually includes "barrister," "counsellor", and "solicitor," in the sense in which those terms are used in England.
Baliff (A Court Attendant)	One to whom some authority, care, guardianship, or jurisdiction is delivered, committed, or entrusted; one who is deputized or appointed to take charge of another's affairs; an overseer or superintendent; a keeper, protector, or guardian; a steward.
Barrister	In English law, an advocate; a counsellor learned in the law who has been admitted to plead at the

bar, and who is engaged in conducting the trial or argument of causes. To be distinguished from the attorney who draws the pleadings, prepares the testimony, and conducts matters out of court.

Battery — An unlawful beating, or other wrongful physical violence or constraint, inflicated on a human being without his consent.

Assault — An intentional, unlawful offer of corporal injury to another by force, or force unlawfully directed toward another person, under such circumstances as create well-founded fear of imminent peril, coupled with apparent present ability to execute attempt, if not prevented.

Circuit Courts — Courts whose jurisdiction extends over several counties or districts and of which terms are held in the various counties or districts to which their jurisdiction extends.

Citation — A writ issued out of a court of competent jurisdiction, commanding a person wherein named to appear on a day named and to do something therein mentioned, or to show cause why he should not. An order or summons by which a defendant is directed or notified to appear.

Common Law — That body of law and juristic theory which was originated, developed, and formulated, and is administered in England, and has been adopted by most of the states and peoples of Anglo-Saxon stock. The ancient custom of any state or nation which is of general and universal application, thus marking off special or local rules or customs.

Corpus Delicti — The body of a crime. The substance or foundation of a crime; the substantial fact that a crime has been committed. The body (material substance) upon which a crime has been committed, e.g., corpse of a murdered person, charred remains of house burned down, etc.

Court of Common Pleas — In American law, the name sometimes given to a court of original and general jurisdiction for the trial of issues of fact and law according to the principles of common law.

De novo — Anew; afresh; a second time. A venire de novo is a writ for summoning a jury for the second trial of a case which has been sent back from above for a new trial.

Deposition — A form of taking a statement to be later used in court as evidence, wherein the witness is duly sworn and both parties to the anticipated litigation are represented by counsel.

Dying Declaration — A statement made by a dying person concerning the circumstances which brought about his/her death. Subject to certain conditions, dying declarations may be admitted as evidence.

Evidence — All means by which an alleged matter of fact is established or disproved.

- circumstantial evidence — Evidence in which the existence of principle facts is inferred from one or more circumstances.

- demonstrative evidence — Syn: real evidence. Evidence furnished by the view or inspection of things such as photographs, documents, X-ray plates, etc.

- direct evidence — Evidence by a witness regarding facts of which he/she gained knowledge through his/her immediate experience, e.g., an eye witness.

- hearsay evidence	Evidence not based upon the personal knowledge of the witness but on information conveyed to him/her by another person not sworn as a witness.
- trace evidence	Evidence based upon the examination of small amounts of biological materials such as blood or upon specimens of soil, textile fibers, etc.
Ex parte	On one side only; by or for one party. A judicial proceedings, order, injunction, etc,; are ex parte when they are taken or granted at the instance and for the benefit of one party only, and without notice to, or contestation by, any person adversely interested.
Exhibit	Any object admitted in court as evidence.
Expert	In general, an individual determined by the court to have sufficient expertise in a given area to render an opinion based on information provided in his/her area of specialization.
Fornication	Unlawful sexual intercourse between two unmarried persons. If one of the persons is married and the other not, it is fornication on the part of the latter, though adultery on the former. In some jurisdictions by statutes, it is adultery on the part of both of them if the woman is married, whether the man is married or not.
Habeas Corpus	Literally, "you have the body". The name given to a variety of writs having for their object to bring a party before a court or judge. The sole function of the writ is to release from unlawful imprisonment.
Hearsay	See: Evidence.

Indictment	An accusation in writing found and presented by a grand jury, legally convoked and sworn, to the court in which it is impaneled, charging that a person therein named has some act, or been guilty of some omission, which by the law is a public offense, punishable on indictment.
Injunction	A prohibitive writ issued by a court, at the suit of a complainant, directed to a party, forbidding him to do some act which he is threatening or attempting to commit, or restraining him in the continuance thereof, i.e., such as being injurious to the plantiff.
In Pari Delicto	In equal fault; equally culpable or criminal; in a case of equal fault or guilt.
Inquest	The judicial inquiry made by a jury summoned for the purpose is called an "inquest". The inquiry by a coroner, termed a "coroner's inquest," deals with the manner of death of anyone who has been slain or has died suddenly in prison.
Inquisition	An inquiry or inquest; particularly, an investigation of certain facts made by a sheriff, together with a jury impaneled by him for the purpose.
Jurisdiction	It is the authority by which courts and judicial officers take cognizance of and decide cases. The legal right by which judges exercise their authority.
Lawyer	A person learned in the law; as an attorney, counsel, or solicitor; a person licensed to practice law.
Lien	A charge or incumbrance upon property. A lien on land is the right to have it sold or otherwise applied in satisfaction of debt.

Litigation	Contest in a court of justice for the purpose of enforcing a right. A suit at law.
Malfaisance	Evil-doi ; ill conduct; the doing of an a which is wholly wrongful and unlawful.
Mens Rea	A guilty mind; a guilty or wrongful purpose; a criminal intent. Guilty knowledge and willfulness.
Mistrial	An erroneous trial; a trial of an action which cannot stand in law because of want of jurisdiction, or a wrong drawing of jurors, or disregard of some other fundamental requisite.
Mors In Tabula	Death on the operating table.
Murder	The premeditated killing of a human being.
Nulla Bona	No goods. The name of the return made by the sheriff to a writ of execution when he has not found any goods of the defendant within his jurisdiction on which he could levy.
Obiter Dictum	Words of a prior opinion entirely unnecessary for the decision of the case. Statements in opinions wherein courts indulged in generalities that had no actual bearing on issues involved.
Posse	Short for posse comitatus. A force with legal authority; a detachment, as police.
- posse comitatus	The power or force of the country. The entire population of a country above the age of 15 which a sheriff may summon to his assistance in certain cases, as to aid him in keeping the peace, pursuing and arresting felons, etc.
Prima Facie Case	Such as will suffice until contradicted an overcome by other evidence. A prima facie case is one which is established by sufficient evidence, and can be overthrown only by rebutting evidence adduced on the other side. A grand jury is bound to find a true bill of indictment if the evidence before them creates a prima facie case against the accused; and for this purpose, therefore, it is not necessary for the defense.
Probate	Relating to the proof of wills. The proof before an ordinary surrogate register, or other duly authorized person, that a document produced before him/her for official recognition and registration and alleged to be the last will and testament of a certain deceased person is such reality.
Res Ipsa Loquitur	"The thing speaks for itself." Rubuttable presumption that defendant was negligent, which arises upon proof that instrumentally causing injury was in defendant's exclusive control, and that the accident was one which ordinarily does not happen in absence of negligence.
Res Judicata	A matter once judicially decided is finally decided. A matter adjudged; a thing judicially acted upon or decided; a thing or matter settled by judgement.
Respondeat Superior	"Let the master answer." A master is liable in certain cases for wrongful acts of this servant and a principal for those of his agent.
Solicitor	In English law, a legal practitioner in the court of chancery. The words "solicitor" and "attorney" are commonly used indiscriminately, although they are not precisely the same; an attorney being a practitioner in the courts of equity.

Surety	One who undertakes to pay money to do any other act in the event that his/her principal fails therein.
- surety of the peace	A species of preventive justice, and consists in obliging those persons whom there is probably ground to suspect of future misbehavior to stipulate with and to give full assurance to the public that such offense as is apprehended shall not take place, by finding pledges or sucurities for keeping the peace or for their good behavior.
Subpoena	A process to cause a witness to appear and give testimony, commanding him/her to lay aside all pretenses and excuses, and appear before a court or magistrate therein named at a time therein mentioned to testify for the party named under a penalty therein mentioned.
Subpoena Duces Tecum	A process by which the court commands a witness who has in his/her possession or control some document or paper that is pertinent to the issues of a pending controversy, to produce it at the trial.
Testes	Witnesses (Latin).
Testator	One who makes or has made a testament or will; one who dies leaving a will.
Testamentum	A will, or last will. Written testimony of conveyance authenticated by witness.
Tort	A private or civil wrong or injury.
Joint Tort-Feasors	The parties must either act together in committing the wrong, or their acts, if independent of each other, must unite in causing a single injury.

True Bill	In criminal practice, the endorsement made by a grand jury upon a bill of indictment, when it finds it sustained by the evidence laid before it and are satisfied of the truth of the declaration.
Vagrant	A person without visible means of support, who is idle, and who, though able to work for his/her maintenance, refuses to do so.
Venue	A neighborhood; the place or country in which an injury is declared to have been done, or fact declared to have happened, and where prosecution is brought for trial.
Verdict	A ture declaration. The formal and unanimous desicion or finding made by a jury, impaneled and sworn for the trial of a cuase, and reported to the court (and accepted by it), upon the matters or questions duly submitted to it upon the trial.
Volenti Non Fit Injuria	He who consents cannot receive an injury.
Voir Dire	The preliminary examination which the court may make of one presented as a witness or juror where his/her competency, interest, etc., is objected to.
Warrant	A writ or precept issued by a magistrate, justice, or other competent authority, addressed to a sheriff, constable, or other officer, requiring him/her to arrest the body of a person therein named, and bring him/her before the magistrate or court, to answer, or to be examined, touching some offense which he/she is charged with having committed.
Writ	A precept in writing, in the name of a state, issued from a court of justice, addressed to a sheriff or

other officer of the law, or directly to the person whose action the court desires to command, either as the commencement of a suit or other proceeding or as incidental to its progress, and requiring the performance of a specified act, or giving authority and commission to have it done.

GLOSSARY OF MEDICAL TERMS

Abbreviations used:

Adj. - adjective
Syn - synonym

Abortifacient

A drug which produces abortion by stimulating contractions of the uterine muscle.

Abortion

1. The expulsion of the fetus, usually in the first trimester of pregnancy.

2. The interruption of pregnancy before the state of fetal viability.

Abraded margin

Syn: abrasion ring. A zone of abrasion surrounding the entrance wound of a bullet, caused by the stretching of the skin and the rotational movement of the projectile.

Abscess

An area of tissue destruction containing pus.

Acid phosphatase

A group of enzymes occurring in many cells of the body. The only secretion in which acid phosphatase is found is that of the prostate gland. The finding of acid phosphatase in vaginal washings or on clothing is thus regarded as indicative of the presence of semen.

Activation analysis

Syn: neutron activation analysis, radio activation. Any analytical method for the detection of trace elements in biological materials. Irradiation by nuclear particles induces radioactivity in these elements which can then be detected by their characteristic emissions. The forensic applications of activation include the analysis of hairs and nails to establish their individuality and the examination of bullet entrance areas for the determination of the firing distance.

Addiction

A severe psychological and physical dependence upon a drug such as alcohol or a narcotic. Sudden abstinence from the drug will result in withdrawal symptoms.

Adipocere

Syn: adipocire. A waxy, greyish-white substance consisting largely of free fatty acids, produced in the fatty tissues of the body by the hydrolysis of fats in a moist environment.

Agonal	(Adj.) Related to the last moments of life or to the death struggle.
Air embolism	See: Embolism
Alcohol	A hydroxy derivative of aliphatic hydrocarbons. When used without qualification, the term denotes ethyl alcohol (C_2H_5OH). Syn: ethanol, grain alcohol, the active constituent of alcoholic beverages. Alcohols are central nervous system depressants.
- methyl alcohol	Syn: methanol, wood alcohol (CH_3OH). A common industrial solvent and constituent of resins and varnishes. It is much more toxic than ethyl alcohol.
Alcohol dehydrogenase	Syn: A.D.H. A zinc-containing enzyme in the liver catalyzing the early stages in the oxidation of ethyl alcohol and some of the higher alcohols.
Amniotic fluid	Syn: liquor amnii. The liquid in the amniotic sac in which the fetus is suspended. It contains cells of the fetal skin and lanugo hairs. It is usually clear or slightly milky but may contain blood, bilirubin or meconium. Entrance of amniotic fluid into maternal veins causes amniotic fluid embolism.
Amphetamines	Syn: "speed." A group of drugs including amphetamine sulphate, methylamphetamine and dextroamphetamine. The amphetamines are central nervous system stimulants which in therapeutic doses cause elevation of mood, alertness, increase in mental ability and reduction of appetite. In toxic doses they cause restlessness, irritability, hallucinations and panic states. Cerebral hemorrhage may be a terminal event.
Analgesic	A drug which relieves pain.
Anaphylaxis	An acute and sometimes fatal reaction occurring within seconds or minutes after exposure to an allergen to which an individual is hypersensitive.
Aneurysm	A localized bulging of a blood vessel or chamber of the heart arising from a weakness of its wall.

- arterio-venous aneurysm	An aneurysm involving a direct communication between an artery and a vein. Arterio-venous aneurysms may be congenital in origin or be caused by an injury.
- berry aneurysm	Syn: congenital aneurysm. An aneurysm involving one of the arteries at the base of the brain. Rupture of a berry aneurysm is a common cause of sudden death in young or middle aged adults.
- dissecting aneurysm	A diffuse swelling of an artery caused by the penetration of blood between the various layers of the vessel wall.
- fusiform aneurysm	A spindle shaped dilation of a blood vessel involving its entire circumference.
- mycotic aneurysm	An aneurysm arising in a weakness of a blood vessel wall caused by infection.
- saccular aneurysm	A sac-like aneurysm arising in a localized weakness of the vessel wall involving only a portion of the circumference and connected to the lumen of the vessel by a narrower neck.
- traumatic aneurysm	An aneurysm arising in a weakness of a blood vessel caused by injury.
Anoxia	Lack of oxygen
Antemortem	(Adj.) Premortem: present or occurring before death.
Anterior	(Adj.) Ventral: before, in front of, facing toward the front.
Anthropology	The study of the origin, distribution, customs and characteristics of mankind.
Antimony	A poisonous metallic element in common industrial use. Its medicinal use is now confined to a few preparations employed in tropical medicine.
Aorta	The main artery arising from the heart and giving rise to the entire systemic arterial system.
Arachnoid	The middle membrane covering the brain and spinal cord.

Arsenic	A poisonous element and a common constituent of weed killers, insecticides and rat killers. Formerly widely employed in medicine.
Artificat	A change brought about artificially and not by natural processes.
Arteriosclerosis	A group of pathological conditions affecting arteries and resulting in hardening, thickening, loss of elasticity of the wall, and often in narrowing of the lumen.
Artery	A blood vessel carrying blood on its way from the heart to the tissues of the body.
- coronary arteries	The two arteries arising from the aorta and supplying blood to the heart muscle.
Asphyxia	Death caused by lack of oxygen or by the inability of the tissues to utilize oxygen.
- chemical asphyxia	Asphyxia produced by a chemical agent which prevents the combination of hemoglobin and oxygen (e.g., carbon monoxide), or the release of oxygen from hemoglobin (e.g. cyanide).
- traumatic asphyxia	Asphyxia caused by compression of the chest and prevention of respiratory movements. Common in industrial accidents.
Atheroma	A localized form of arteriosclerosis consisting of a focal proliferation of fibrous tissue and the deposition of fats and resulting in a narrowing of the lumen. Atheromata commonly involve the coronary arteries and the arteries of the brain and aorta.
Atomic absorption spectroscopy	A technique by which metals (e.g., lead, arsenic, etc.) in biological samples may be identified and measured. The sample of blood, urine or tissue is first processed to release the toxic metal to its atomic form and a portion of metal in the sample is then aspirated into a beam of light of a specific wavelength which will be absorbed by the metal in the sample. By comparing the light absorption of known metal standards to that absorbed by the sample, the type and quantity of the metal in the biological sample may be determined.
Autoeroticism	Sexual gratification without a partner.

Autolysis	The dissolution of cells and tissues by enzymes normally present in them. Autolysis is the earliest morphological postmortem change and is the predominant change in sterile cadavers such as newborn infants. It is also the main mechanism in the dissolution of infarcts.
Autopsy	Syn: necropsy, postmortem. A dissection of the body after death to determine the cause of death and to study the changes in the tissues caused by disease or violence. The term is often used to include any subsequent examination, including microscopic or chemical.
- psychological autopsy	A review of investigative findings and the performance and evaluation of a series of structured interviews conducted by a psychiatrist or trained psychologist with close friends, acquaintances, and relatives of a deceased person in order to determine his psychological makeup during life. This information may be of assistance in determining factors related to the death.
- sociological autopsy	A review of related sociologic and demographic considerations of a deceased person in an attempt to correlate these with the circumstances of death and thereby identify social conditions common to several or many deaths in the expectancy of identifying common etiologic or mitigating conditions.
Avulsion	A tearing away of part of a tissue.
Ballistics	The study of the behavior of projectiles.
- external ballistics	The behavior of projectiles in flight.
- internal ballistics	The behavior of projectiles within the weapon from which they are fired.
- terminal ballistics	The behavior of projectiles when striking the target.
- wound ballastics	The mechanism of wound production by projectiles.
Barbituates	Syn: "barbs," "candy," "goof balls," "peanuts." A group of drugs used as sedatives, hypnotics and anesthetics. They include thiopental (ultrashort-acting), pentobarbitol and secobarbitol (short-acting), amobarbital (intermediate) and phenobarbitol (long-acting).

Barotrauma	Injuries, such as rupture of the eardrum, caused by sudden changes in atmospheric pressure.
Battered child syndrome	See: Syndrome.
Benzedrine	Brand of amphetamine sulphate (Smith, Kline and French Laboratories). Benzedrine tablets syn: "bennies," "hearts," "peaches," "roses."
Berry aneurysm	See: Aneurysm.
Bestiality	Sexual intercourse with an animal.
Birth injury.	Syn: birth trauma. An injury to the infant sustained during birth. Common birth injuries include fractures of the skull, rupture of the dural venous sinuses brain damage, stretching of nerves and dislocation of joints.
Blister	Syn: bulla, vesicle. An elevation of the superficial layer of the skin or mucous membrane containing fluid. When small often called a vesicle or bleb; when large, a bulla. Blisters may be antemortem or postmortem in origin.
Blood groups	Individuals who have the same type of blood with regard to the two major red cell antigens A and B. Persons having antigen A only are said to be blood group A; those possessing antigen B only, blood group B; those having both antigens, blood group AB; and those having neither antigen, blood group O. Also includes other groups such as M, N, S, etc.
Bone marrow embolism	See: Embolism
Brandhematoma	An extradural collection of brick-red, friable blood clots in bodies which have been exposed to great heat. Differentiation from antemortem extradural hematoma may be difficult. The absence of skull fractures and a high carbon monoxide content of the clot favor brandhematoma.
Bruise	See: Contusion
Brush burn	See: Abrasion
Buckshot	Shotgun pellets having a diameter of more than .22 inches (9-12 pellets per shell).

Buggery	See: Sodomy.
Bullet	A projectile fired from a rifled weapon. Bullets may be soft (lead) or jacketed.
Bullet embolism	See: Embolism.
Burking	A homicidal form of traumatic asphyxia employed by Burke and Hare in which one of the assailants sat on the chest of an intoxicated victim.
Burn	An injury caused by dry heat.
Cadaver	A dead body, a corpse.
Cafe coronary	Asphyxia due to the impaction of a bolus of food in the larynx or trachea.
Cassion disease	Syn: decompression sickness, "the bends." A form of gas embolism seen in divers, tunnel workers, etc. who are being brought quickly from an environment of high atmospheric pressure to one of lower pressure. It is due to the release of bubbles of nitrogen from the blood.
Caliber	The inside diameter of the barrel of a firearm. The bore diameter of a rifled barrel, usually measured from land to land, also is used to designate bullet diameter.
Calliphora vomitoria	Syn: blow fly, blue bottle fly. A common fly which deposits its eggs on recently dead bodies and the larvae of which play an important part in the disintegration of the tissues.
Callus	The tissue which gradually connects the fragments of a broken bone. Callus at first consists of fibrous tissue which is later converted into bone. The microscopic and X-ray appearance of a callus is roughly indicative of its age and thus may often be of importance in cases of suspected battered child syndrome.
Cantharides	Syn: Spanish fly. The active component of the extract of the tissues of the blister beetle (Cantharis vesicatoria) which is wrongly regarded as having aphrodisiac properties but may cause severe kidney damage.

Carbon Monoxide	A toxic gas produced by the imcomplete combustion of organic materials. It combines with hemoglobin thus preventing the carriage of oxygen and producing a state of asphyxia. Carbon monoxide is an important constituent of motor exhaust and coal gas.
Carbon Tetrachloride	A halogenated hydrocarbon which is a common industrial solvent and is particularly toxic to the liver.
Cardiac Tamponade	Compression of the heart by the rapid accumulation of fluid in the pericardial sac. Cardiac tamponade is usually caused by bleeding into the pericardial cavity due to rupture of the heart or one of the coronary arteries.
Cardiomyopathy	A primary disease of the heart muscle.
Carnal knowledge	Sexual intercourse of an individual below the legal age of consent.
Cartridge	Syn: round. The complete unit of ammunition consisting of projectile, cartridge case, primer and propellant and, in the case of shotgun ammunition, the shell, pellets and wads.
Cellular death	See: Death
Center fire ammunition	Ammunition in which the primer is contained in a well located in the center of the base of the cartridge case.
Cerebrospinal fluid	The clear fluid which is secreted by the choroid plexuses in the brain and which circulates through the ventricular system of the brain and the subarachnoid space.
Cervix	Syn: cervix uteri. The neck of the uterus connecting the uterine cavity with the vagina and consisting of the external os and the internal os.
Choke	A constriction in the muzzle end of a shotgun barrel which narrows the area of scatter of shotgun pellets.
Choking	Asphyxia caused by the mechanical occlusion of the upper respiratory passages, e.g. by a bolus of food.

Chromatin	Particulate matter in the nuclei of cells stainable with basic dyes. It is the carrier of genetic information.
- sex chromatin	A particle of chromatin present only in cell nuclei of female individuals. It represents an X chromosome and has been used to determine the sex of fragmentary human remains.
Clitoris	An erectile structure, one of the female genital organs located beneath the anterior commissure of the labia minora.
Clot	A soft, semi-solid coagulum formed in stagnant blood, its structure being largely determined by gravity. It thus differs from a thrombus.
- chicken fat clot	A bright yellow layer, consisting predominantly of white blood cells, and forming the uppermost part of a clot. The position of the chicken fat clot has been used in attempts to determine the position of the body after death.
- currant jelly clot	A dark red layer, consisting of predominantly red blood cells and forming the lower part of a clot.
- postmortem clot	A clot formed in the blood vessels, chambers of the heart or sites of hemorrhage after death.
Clotting	See: Coagulation
Coagulation	Syn: Clotting. The transformation from a liquid state to a solid or semi-solid mass. Usually applied to the formation of fibrin in blood resulting in a clot or thrombus.
Cocaine	Syn: "bernice," "candy," "coke," "C," "corine," "dust," flake," "gold dust," "snow," "stardust." An alkaloid from the leaves of the Erythroxylon trees native to Peru and Bolivia. Systemically cocaine is a cerebral stimulant, topically a local anesthetic. Used illicitly it is usually sniffed in the form of a white powder.
Codeine	One of the alkaloids of opium. Its analgesic effect is weaker than that of morphine, but is a better suppressant of the cough reflex.

Coma	A state of deep unconsciousness from which a person cannot be aroused. Causes of coma include poisonings, brain injuries, stroke, diabetes mellitus and uremia.
Concussion	A diffuse injury to an organ caused by a violent impact. Usually applied to the brain (commotio cerebri).
Congenital Aneurysm	See: Aneurysm.
Contact flattening	The flattening of muscles which are in contact with a hard surface during rigor mortis.
Contre coupe injury	An injury of an organ occurring on the side opposite to that suffering a blow or impact, resulting from impact of the organ on the interior of the body wall. The term is usually applied to the brain but other organs such as the lungs may suffer contre coup injuries.
Contusion	An injury without laceration to the superficial tissues of an organ or the body surface; caused by a blunt impact resulting in a hemorrhage into the tissue beneath the skin. Contusions are usually caused by violence but may be spontaneous in certain blood disorders. During life the color of contusions changes gradually from red to green to yellow, giving a rough indication of their age. Contusions sustained shortly prior to death may at first show no discoloration of the skin surface but may become more noticeable after the blood in the capillaries has settled to another part of the body.
Cooximeter	A spectrophotometric instrument designed specifically to measure absorption of visible light by the hemoglobin molecule. The degree of light absorption by the molecule changes as the hemoglobin combines with the increasing amounts of carbon monoxide. By monitoring this change in light absorption, the instrument gives a direct reading of the percent saturation of hemoglobin by carbon monoxide.
Coronal	(Adj.) In the transverse direction

Coronal Plane	An imaginary plane bisecting the body from side to side at right angles to the sagittal plane. This term is useful in describing gunshot wounds.
Coronary Thrombosis	Occlusion of one of the coronary arteries by a thrombus. One of the causes of a "heart attack."
Coroner	An official appointed or elected to investigate certain types of fatalities and to preside over inquests. He/she may or may not be a physician.
Cranial Sutures	The fibrous lines of union between the bones of the cranium. The gradual disappearance of the cranial sutures is one of the anatomical features upon which an estimate of the age of skeletal remains may be based.
Cranium	That part of the skull which encloses the brain.
Crib death	See: Sudden Infant Death Syndrome
Cricoid cartilage	The lowermost cartilage of the larynx.
Crimp	Syn: rolled crimp. In shotgun ammunition the folded-over margins of the shell holding the overshot wadding in place.
- star crimp	Syn: pie crimp. A pleated crimp eliminating the need for overshot wadding.
Cut	Syn: incised wound, slash, slice. A wound caused by a sharp object, usually of metal or glass. The wound is longer than deep and tends to gape. Its edges are usually not contused, distinguishing it from a laceration.
"Cut"	To adulterate a drug, usually by an admixture of starch or lactose.
Cutis anserina	Syn: goose flesh, goose pimples. A roughening of the skin caused by the contraction of the erector muscles of the hairs. In the living person it is caused by fear or exposure to cold. In the cadaver, it is a manifestation of rigor mortis. The presence of cutis anserina in a body recovered from water was at one time regarded as indicating that death had occurred in water. This view is no longer held.

Cyanides	Common industrial chemicals and constituents of insecticides. Cyanides produce rapid cellular anoxia by inactivation of the respiratory enzyme cytochrome oxidase.
Cyanosis	A bluish or greyish discoloration of the skin and mucous membranes due to the circulation of insufficiently oxygenated blood.
Cylinder	The circular magazine of a revolver.
Death	The permanent cessation of all vital functions.
- cellular death	The permanent loss by the cell of its functional integrity. The earliest manifestation of molecular death appears to be an irreversible change in the selective permeability of the cell membrane.
- somatic death	Syn: clinical death. The permanent cessation of respiration and circulation. Absence of response to external stimuli, of spontaneous muscular movements and lack of brain function as determined by the electroencephalogram have recently been added to the criteria on which the definition of somatic death marks the extinction of the biological and legal personality.
Deciduous teeth	Syn: milk teeth. The first dentition of the child consisting of 20 teeth.
Defense wound	See: Wound
Delirium	A state of mental disorientation, usually temporary.
Delusion	A false belief, contrary to reality, which cannot be corrected by reasoning.
Dementia	An irreversible mental deterioration, the end result of many intoxications or neurological disorders.
Dermal nitrate test	See: Paraffin test.
Dexedrine	Brand of dextroamphetamine sulphate (Smith, Kline & French Laboratories). Dexedrine tablets, syn: "dexies," "hearts," "oranges."
Diacetyl morphine	See: Heroin

Diatoms	Unicellular microscopic algae possessing a siliceous wall. Their presence in the lungs and bone marrow of bodies recovered from water has been used in the diagnosis of drowning.
Dilatation & Curettage	Syn: D & C. A surgical operation consisting of the dilatation of the cervical canal and the scraping of the lining of the uterine cavity.
Diptera	An order of insects consisting of the true flies, most possessing a single pair of wings. The order includes the species Calliphora vomitoria which infests recently dead bodies and the larvae of which feed upon the tissues.
Disinterment	Syn: exhumation. The recovery of a body from the earth. Usually applied to the removal of a body from a grave for the purpose of medical examination or transportation to another burial site.
Distal	(Adj.) Further from the trunk of from the origin.
Dorsal	See: Posterior
Drowning	Death due to the immersion of the nose and mouth in water or other fluid. Until recently drowning was regarded as purely asphyxial in nature. However, it is said that only 10-12 percent of drownings involve true asphyxia. The vast majority of cases are associated with the inhalation of large quantities of water which causes some degree of anoxia as well as acute disturbance in the electrolyte balance of the blood.
- dry drowning	Asphyxia believed to be caused by laryngeal spasm due to the aspiration of small quantities of fluid, or by vagal response to immersion, resulting in cardiac standstill.
- wet drowning	Drowning following which large amounts of fluid are found in the lungs.
Dura mater	The outer and strongest of the three membranes surrounding the brain and spinal cord.
Ecchymosis	An extravasation of blood into the skin, mucous or serous membrane. An ecchymosis is larger than a petechial hemorrhage.

Edema	The presence of excess fluid in the tissue. Edema may be localized as in an area of inflammation or may involve the entire body.
Ejector	A mechanism which expels the empty cartridge case from a firearm after it has been withdrawn from the firing chamber by the extractor.
Electrocution	Death caused by the passage of an electric current through the body. The usual mechanism of death is ventricular fibrillation or paralysis of the respiratory center.
Embalming	A method of preserving the cadaver by preventing putrefaction. Embalming usually involves the perfusion of the vascular system with a fixative fluid and the introduction of such fluid into the serous cavities by means of a trochar. Various dyes such as eosin may be added to the perfusion fluid.
Embolism	The plugging of a blood vessel by an embolus. When used without qualification the embolus consists of a thrombus.
- air embolism	Occlusion of blood vessels by bubbles of air which may be introduced into the blood stream by positive pressure as in cases of criminal abortion, by negative pressure of stab wounds of the neck. Air embolism must be distinquished from the presence of gas due to putrefaction.
- amniotic fluid embolism	Embolism by the solid constituents of amniotic fluid. The thromboplastic activity of amniotic fluid also leads to extensive intravascular fibrin formation.
- bullet embolism	Embolism by a bullet or bullet fragment.
- bone marrow embolism	Occlusion of blood bessels by fragments of bone marrow. It may follow extensive fractures or orthopedic operations.
- fat embolism	Occlusion of capillary blood vessels by fat droplets. It is most commonly seen in the vessels of the brain, lungs and kidneys and follows fractures or contusions of adipose tissue.
- gas embolism	Embolism by an insoluble gas as may be seen in caisson disease.

- pulmonary embolism	Occlusion of the pulmonary artery or its main branches by an embolus. A common cause of sudden death.
- talcum embolism	Embolism by particles of talcum powder in the circulation. It may lead to the formation of small granulomata in the lungs. See: Junkie's lung.
Embolus	A mass of undissolved matter which travels through the bloodstream and may plug a vessel which is too narrow to permit passage.
Embryo	Syn: conceptus. The developing child in the uterus during the first trimester of pregnancy.
Epiglottis	A leaf-shaped strucutre situated at the root of the tongue protecting the opening of the larynx during swallowing.
Epiglottitis	An inflammation of the epiglottis usually caused by Hemophilus influenza. A cause of rapid death in young children.
Epilepsy	A group of disorders marked by episodic impairment or loss of consciousness and, frequently, convulsions.
Epiphyseal injury	Dislocation of the epiphysis of a bone often caused by forceful pulling of an extremity. A common type of injury in the battered child syndrome.
Epiphysis	A part of a bone which is separated from the main part during the period of active growth by a layer of cartilage and which fuses with the main part during adolescence and early adult life.
Ethyl Alcohol	See: Alcohol
Exhibitionist	A person obtaining sexual gratification by displaying parts of the body including the sexual organs to a member of the opposite sex.
Exhumation	See: Disinterment.
Exsanguination	Death due to loss of blood from the circulatory system.
Extractor	A device removing the fired cartridge from the firing chamber.

Fallopian tubes	Syn: oviducts, uterine tubes. A pair of muscular tubes connecting the region of the ovaries to the cavity of the uterus.
Falx cerebri	A fold of dura matter separating the cerebral hemispheres and containing in its base the sagittal sinus.
Fat embolism	See: Embolism
Fetus	Syn: conceptus. The developing child in the uterus during the second and third trimesters of pregnancy.
Firing chamber	The chamber in a firearm in which the cartridge rests in position to be fired.
Firing pin	A device which strikes and thus ignites the primer in a cartridge.
Flail chest	A chest having lost stability as the result of multiple rib fractures. The loose rib fragments interfere with the inspiratory expansion of the lungs.
Fontanelle	A soft spot between the cranial bones of a fetus or infant. Normally the newborn infant has two fontanelles, the anterior which is located between the frontal and parietal bones and which closes at the age of about 18 months and the parietal and occipital bones and which closes at about 6 weeks.
Forensic	(Adj.) Applied to the law.
- forensic medicine	Syn: legal medicine. Those parts of medical knowledge which are applied to legal problems.
Fouling	The deposition of small metal fragments surrounding the entrance wound of a bullet.
Fracture	A break in the bone.
- bumper fracture	A fracture of one or both legs below the knee caused by the bumper of a motor vehicle. It is usually a compound fracture.
- comminuted fracture	A fracture having several fragments due to splintering of the bone.
- compound fracture	A fracture communicating with the outside through a wound.

Galton, Francis	(1822-1911) English scientist who introduced identification by fingerprints.
Gangrene	The death of an extremity or portion of an organ in the living organism.
Garrotting	Asphyxia caused by the twisting of a ligature around the neck.
Gas Embolism	See: Embolism
Gas liquid chromatography (GLC)	An analytic technique by which drugs may be separated by partitioned chromatography at high temperature. The tentative identification of drugs may be made by comparing the chromatographic behavior of pure drug standards with unknowns.
Gauge	The unit of measurement for shotgun bore diameters, disregarding any choke. The gauge is equal to the number of solid lead balls of the bore diameter which weigh one pound.
Gestation	The period of intrauterine development.
Glottis	The voice-producing part of the larynx consisting of the vocal cords and the space between.
Graze	An abrasion of the skin caused by contact with a rough surface. The direction of the graze may be indicated by a sharply demarcated beginning and tags of epidermis at the end.
Hematoma	A collection of blood in the tissues resulting from hemorrhage.
Hemolysis	Syn: laking of blood. The disintegration of red blood cells and escape of hemoglobin into the surrounding fluid.
Hemoperitoneum	The presence of blood in the abdominal cavity.
Hemorrhage	The escape of blood from a blood vessel.
Hemothorax	The presence of blood in a chest cavity.
Hallucination	A false perception, auditory, olfactory or visual which has no basis in reality.
Hanging	A type of ligature strangulation in which the constricting force is due to gravity.

Hashish	Syn: "hash." The resinous juice of the flowering tops and upper leaves of the female hemp plant, cannabis sativa, sold in the form of cakes or blocks. Usually smoked in a pipe. Due to its high content of cannabinols, it is more potent than marijuana.
Heat exhaustion	A state of collapse following exposure to high temperatures caused by depletion of the body's electrolytes and fluids. Clinically, it resembles shock.
Heat stroke	A state of collapse following exposure to high temperatures. It is caused by injury to the body's heat regulating mechanisms.
Heroin	Syn: "H," "Harry," "horse," "joy powder," "scat," "schmeck," "smack," "shit." Diacetyl morphine. A semi-synthetic made by the acetylation of morphine. Not legally available in the United States, Canada or Great Britain. Sold illicitly as a white powder usually heavily adulterated with lactose or quinine. Usually injected intravenously but may be smoked or snuffed.
Homocide	The killing of one human being by another.
Homosexual	Syn: "fag," "fairy," "fruit," "queen," "queer." An individual sexually attracted to members of the same sex. When used without qualification indicates a male homosexual.
Horizontal plane	An imaginary plane traversing the erect body parallel with the level ground. Useful in describing gunshot wounds.
Hymen	Syn: maidenhead. A membrane which partially occludes the external opening of the vagina.
Hyoid bone	A U-shaped bone in the neck above the larynx. From its central body projects the greater and lesser cornua. The latter are frequently broken in cases of manual strangulation.
Hypnotic	A drug which produces sleep.
Hypostasis	The settling of blood after death into the dependent parts of the body. In this skin this is manifested by lividity. In the internal organs the congestion due to hypostasis.
Hypothermia	A state of abnormally low body temperature, usually below 95^{o} F.

Hypoxia	Lack of sufficient oxygen.
Iatrogenic	(Adj.) Caused by the physician. Usually applied to an illness or injury caused by injudicious therapy.
Idiosyncrasy	An unusual or individual reaction, usually to a drug.
Imprint	An abrasion of the skin caused by localized pressure.
Incest	Sexual intercourse between closely related individuals.
Infanticide	The killing of an infant by its mother.
Infarct	The death of a portion of an organ in the living organism due to sudden occlusion of its blood supply.
Instar	A stage in the development of an insect larva.
In vitro	In the glass, in the test tube, under experimental conditions.
Ischemia	A state of inadequate blood supply to an organ or tissue.
Jacket	A complete or partial shell of hard metal such as copper or nickel surrounding the soft metal core of a bullet.
Junkie's lung	Lungs showing microscopic granulomata caused by the intravenous injection of insoluble materials such as talcum or starch granules. Seen in drug addicts. Sudden death due to cor pulmonale has been recorded.
Laceration	Syn: split, tear. A wound caused by crushing or tearing of the tissues, usually showing a break in the surface.
Lands	The areas on the internal surface of a firearm barrel which are located between the rifling grooves.
Lanugo	Fine hairs which appear at the end of the sixth month of gestation and cover the fetus during the seventh and eighth months. Lanugo hairs have been shed by the time of birth except in the region of the eyebrows, the eyelids and the scalp. The presence of lanugo hairs in maternal blood vessels is evidence of amniotic fluid embolism.

Larva	Syn: maggot. A stage of metamorphosis of certain insects between the egg and the pupa. The larva may molt several times, each stage being known as an instar.
Larynx	Syn: voice box. A hollow muscular and cartilaginous structure lined with mucous membrane situated between the hyoid bone and the trachea. Its components include the epiglottis, thyroid, cartilage and cricoid cartilage. It contains the vocal cords.
Lateral	(Adj.) Away from the midline, towards the side.
Lesbian	A female homosexual.
Lesion	Any abnormal change in the structure of a tissue.
Lividity	Syn: livor mortis. A dark red or bluish-red discoloration of the dependent portions of the external surface of the body due to postmortem stasis of blood.
- congestion lividity	Lividity caused by the distension of skin capillaries by blood.
- diffusion lividity	Lividity partly due to hemoglobin staining of the dependent portions of the skin. Diffusion lividity tends to be "fixed" in contrast to congestion lividity.
LSD	Syn: "acid." Lysergic acid diethylamide. A hallucinogenic alkaloid occurring in morning glory seeds. Now usually produced synthetically.
Magnum	(Adj.) Extra large or powerful, as applied to ammunition.
Marbling	The appearance of vascular patterns on the skin after death.
Marginal Abrasion	See: Abraded margin
Malpractice	Medical practice involving negligence by falling below generally accepted standards of conduct.
Malocclusion	A condition in which the teeth of the upper and lower jaws do not meet properly.
Manslaughter	A legal category of homicide, a lesser offense than murder.

Marijuana	Syn: "gage," "grass," "griefo," "hay," "hemp," "jive," "loco weed," "Mary Jane," "mess," "pot," "rope," "Texas tea," "weed." The flowering tops and upper leaves of the female hemp plant (Cannabis sativa), usually sold as a coarse powder and smoked in the form of a hand-rolled cigarette. Its pharmacological activity is believed to be due to tetrahydrocannabinol.
Masochism	An abnormal practice wherein pleasure or sexual gratification is derived from being treated cruelly.
Meconium	The feces of the newborn. The presence of meconium in the amniotic fluid is indicative of fetal distress. The absence of meconium in a normal intestine of a newborn is strong evidence of a live birth.
Medial	(Adj.) Toward the midline.
Medical Examiner	A physician who, by statute, investigates certain types of fatalities by conducting such examinations as are considered necessary.
Medical jurisprudence	Those parts of the law which apply to the practice of medicine.
Mellanby effect	Syn: acute accommodation. For a given concentration of alcohol in the blood, the degree of clinical intoxication is greater when the blood alcohol level is rising than when it is falling.
Meningitis	An inflammation of the membranes surrounding the brain and spinal cord.
Mescaline	A hallucinogenic drug derived from the peyote cactus.
Methadone	A synthetic analgesic drug similar in its effects to morphine and used as a substitute drug in the treatment of narcotic addiction.
Miscarriage	The expulsion of the fetus, usually in the second trimester of pregnancy. See: Abortion
Morphine	A vegetable alkaloid, the principal constituent of opium. Morphine is a powerful analgesic and nervous system depressant with addicting properties.
Mummification	The drying of a dead body or parts thereof to a brown, leathery, parchment-like condition on exposure to a warm and dry environment.

Muzzle	The forward end of a barrel of a firearm.
Muzzle velocity	The speed at which a projectile leaves the barrel of a firearm, expressed in feet or meters per second.
Myocarditis	An inflammation of the heart muscle caused by bacteria, viruses, parasites or by hypersensitivity.
Narcotic	A drug producing stupor, sleep and relief of pain.
Necrophilia	An abnormal attraction to or interest in dead bodies.
Necropsy	See: Autopsy
Necrosis	The death of cells in the living organism.
Nembutal	A brand of pentobarbital (Abbott Laboratories). Nembutal capsules, syn: "nimbys," "yellow jackets."
Neuron	A nerve cell.
Obturation	The sealing of powder gases between the cartridge case and the walls of the barrel. Deficient obturation permits gas leakage from the chamber or ahead of the bullet.
Occiput	The back of the head or the skull.
Odontology	Syn: dentistry. The knowledge of the development, structure and function of the teeth as well as of the pathological processes involving them. The forensic application of odontology are largely concerned with the identification of individuals.
Opium	Syn: "hop," "mud," "tar." The juice of the unripe seed capsules of the poppy plant. (Papaver somniferum). The milky juice is dried and the crude opium is sold as a dark brown gummy substance. Its pharmacological activity is due to a number of alkaloids including morphine and codeine. Crude opium is usually smoked in pipes.
Ossification	The transformation of cartilage or fibrous tissue into bone.
- centers of ossification	Points of ossification, an early stage in the development of the skeleton. The presence of certain centers of ossification is an indication of the age of an individual.

Osteology	The knowledge of the development, structure and function of bones.
Ovary	The female sex gland which secretes sex hormones and in which the ovum develop.
Overlaying	The accidental smothering of a young child in bed by a sleeping adult. Overlaying was formerly regarded as a common event. It is now regarded as rare.
Overshot wad	See: Wad
Oviducts	See: Fallopian tubes
Ovum	The egg or female reproductive cell which after fertilization develops into the embryo.
Paraffin test	Syn: dermal nitrate test, diphenylamine test, Gonzalez test. A test for the nitrates and nitrites of gunpowder residues on the skin. Paraffin casts of the skin are treated with a solution of diphenylamine and dipheylbenzidine. The test is no longer regarded as sufficiently specific.
Parathion	Diethyl-p-nitrophenyl thiophosphate. An organic phosphate ester used as insecticide.
Pathology	Syn: pathologic anatomy. That branch of medicine concerned with the alterations in the structure and function of tissues caused by disease or violence. The practice of pathology includes the performance of autopsies.
Pederasty	Sexual intercourse with boys.
Pedophilia	Sexual interest in children.
Peritoneum	A serous membrane which lines the internal surface of the abdominal walls and envelops the abdominal organs.
Peritonitis	An inflammation of the peritoneum.
Permanent cavity	The tract left in the tissue by the passage of a missle. The diameter of the permanent cavity is usually greater than that of the missile because of the tissue disruption caused by the temporary cavity.
Petechiae	Syn: petechial hemorrhage. Tiny hemorrhages in the skin, mucous membranes or serous surfaces. (See: Tardiew's spots.)

Phalanx	Any one of the small bones of the fingers and toes.
Pharynx	The musculo-membranous tube connecting the oral and nasal cavities with the larynx and esophagus. The portion of the pharynx above the palate is the nasopharynx, that below the palate the hypopharynx.
Phosphatase	See: Acid phosphatase
Pia mater	The innermost of the three membranes surrounding the brain and spinal cord.
Placenta	Syn: afterbirth. A round, flat organ at the site of implantation containing both maternal and fetal blood vessels and through which the fetus receives oxygen and nourishment. The finding of placental tissue in the uterus is absolute proof of pregnancy.
Posterior	(Adj.) Dorsal; behind, to the rear, or facing backwards.
Postmortem	See: Autopsy
Postmortem	(Adj.) Occurring after death.
- postmortem interval	The time between death and the examination of the body.
- postmortem changes	A number of physical and chemical changes which commence immediately after death and eventually lead to complete disintegration of the body.
Powder stippling	See: Tattooing.
Preternatural combustibility	Syn: "spontaneous" human combustion. A state of excessive combustibility of the human body without an external source of fuel. Obesity and alcoholism have been regarded as predisposing conditions.
Primer	An explosive substance in firearm ammunition which is ignited by the percussion of the firing pin and in turn ignites the propellant.
Propellant	The powder in a cartridge which is ignited by the primer and propels the projectile.
Proximal	(Adj.) Nearer to the trunk or the origin.

Psychosis	A group of severe mental disorders in which there is loss of contact with reality and which are usually characterized by hallucinations.
Ptomains	A group of toxic substances produced by the breakdown of proteins during putrefaction. Formerly believed to be a cause of food poisoning.
Pulmonary embolism	See: Embolism
Pupa	The resting stage in the metamorphosis of certain insects between the larva and the adult form.
Putrefaction	The disintegration of the tissues brought about by bacterial action.
- putrefactive gases	Gases evolved in the process of putrefaction, largely hydrogen sulfide, ammonia, methane and carbon dioxide.
Rape	Sexual intercourse with a woman without her consent or with her consent when she was not qualified to give it (when too young, mentally defective, etc.).
Rectum	The terminal portion of the large intestine. It opens to the outside through the anus.
Rhesus factor	A group of antigens carried on the red blood cells first found in the rhesus monkey. Individuals possessing the rhesus factor are said to be "Rh positive," those who do not, are said to be "rh negative."
Rifle	A firearm fired from the shoulder, the barrel of which has rifling on its internal surface.
Rifling	A series of spiral grooves on the internal surface of a firearm barrel designed to impart a spin to the projectile. The number of grooves and their direction (right-handed, left-handed) is one characteristic upon which a classification of firearms is based.
Rigor mortis	Syn: cadaveric stiffening. A stiffening and contraction of the musculature (both voluntary and involuntary) of the body after death.
Rim fire	Ammunition in which the primer is located in a rim surrounding the base of the cartridge case.

Sadism	An abnormal practice in which pleasure or sexual satisfaction is derived from the infliction of cruelty or pain upon another person or animal.
Sagittal	(Adj.) In the anteroposterior direction.
- sagittal plane	An imaginary plane traversing the body in an anteroposterior direction, useful in describing gunshot wounds.
Salicylates	A group of drugs used as analgesics, antipyretics and for topical application. Salicylates are commonly involved in suicidal poisonings in adults and accidental poisonings in children.
Scald	A surface injury caused by moist heat. In the skin the preservation of hairs distinguishes a scald from a burn.
Scratch	An abrasion caused by a pointed object passing over the skin. The heaping up of the epidermis at one end may indicate the direction of the scratch.
Seat belt injury	Abdominal injuries sustained by acute flexion over a seat belt during sudden deceleration. Seat belt injuries include flexion compression fracture of the neck, tears of bowel or mesentery or injury to the pregnant uterus.
Seconal	Brand of secobarbitol (Eli Lilly & Co.). Seconal capsules syn: "pinks," "red birds," "red devils," "seggys."
Secretor	An individual secreting blood group specific substances in the body fluids and secretions such as milk, saliva and seminal fluid. About 80 percent of the population are secretors.
Sedative	A drug which allays excitement. Sedatives include the barbituates, bromides and chloral hydrate. In large doses sedatives may act as hypnotics.
Segmentation	Syn: box car sign. Numerous transverse interruptions of the blood column in the vessels of the choroid of the eye. It has been regarded as one of the earliest signs of death.
Semen	Syn: seminal fluid. A viscous, whitish fluid ejected from the penis during orgasm and consisting largely of spermatozoa and secretions of the prostate gland and seminal vesicles.

Seminal fluid	See: Semen
Septicemia	Syn: blood poisoning, sepsis. The presence of pathogenic bacteria in the blood.
Shock	A condition characterized by pallor, low blood pressure, rapid but shallow pulse and clammy perspiration.
- primary shock	Syn: faint, syncope. A transient loss of consciousness due to fear or violent emotion.
- secondary shock	Syn: oligemic shock, surgical shock, traumatic shock. A state of shock, often progressing to death, caused by a sudden reduction of circulating blood volume.
Shot pellets	Pellets of lead, lead alloy or recently, ferrous metals in shotgun ammunition.
- chilled shot	Especially hardened shot pellets.
Singeling	Syn: branding. An area of burned skin or hair surrounding the entrance wound of a bullet fired at close range and caused by hot gases escaping from the muzzle.
Slug	Syn: rifled slug. A solid projectile made of lead or lead alloy for a smoother bore gun. Slugs have engraved rifling to provide spin and thus ballistic stability.
Smothering	Asphyxia produced by the occlusion of the mouth and nostrils, e.g. by a pillow.
Smudging	An area of blackening produced by powder gases and surrounding the entrance wound of a bullet fired at close range.
Sodomy	Syn: buggery. An abnormal form of sexual intercourse in which the penis of the active participant is inserted into the anus of the passive participant.
Spermatozoa	The mature male reproductive cells produced in the seminiferous tubules of the testis. The main cellular constituent of semen.
Split	Syn: splitting wound. A wound of the skin caused by the compression of the tissue between a hard blunt object or hard surface and bone. A split may resemble a cut but usually shows ragged edges and contusion of the adjacent tissue.

Sprain	The twisting or straining of a joint with injury to the joint capsule or ligaments but without displacement of the bone.
Stab	Syn: penetrating wound, perforation, puncture. A wound caused by the penetration of a pointed instrument. In contrast to a cut, the depth of a stab is greater than its width.
Steering wheel injury	An injury caused by the impact of the steering wheel on the chest and upper abdomen of the driver during sudden deceleration. It frequently includes rupture of the liver and a flail chest.
Stillbirth	The birth of a dead infant during the last trimester of pregnancy or at term. An infant is regarded as stillborn if it has not shown any sign of life while completely external to the mother. See: Abortion and Miscarriage.
Stippling	Syn: powder stippling, tattooing and powder burns. Dispersed particles of burned and unburned gunpowder embedded beneath the skin surface around a bullet wound.
Strangulation	Death caused by compression or constriction of the neck.
- ligature strangulation	Strangulation by a ligature, such as a rope, stocking, towel, etc.
- manual strangulation	Syn: throttling. Strangulation by one or both hands. Manual strangulation frequently causes injury to the thyroid cartilage.
Strychnine	A vegetable alkaloid obtained from the seeds of Stychnos nux vomica. It is a strong nervous system stimulant and convulsant; usually a fatal poison.
Subarachnoid hemorrhage	See: Hemorrhage
Subdural hemorrhage	See: Hemorrhage
Subluxation	A partial dislocation of a joint.
Sudden infant death syndrome	See: Syndrome

Superfecundation	The fertilization on two separate occasions of ova produced during the same menstrual cycle.
Syncope	See: Shock.
Syndrome:	A set of signs and symptoms which occur together.
- battered child syndrome	The presence in a child of multiple injuries caused by repetitive trauma, generally inflicted by the parents. These injuries, which usually vary in age, may include bruises, fractures, separation of epiphyses, eye injuries, subdural hemorrhage and rupture of organs.
- crush syndrome	Kidney failure caused by damage to tubules and precipitation of hemoglobin, following severe crushing injuries, usually of the extremities. A similar syndrome may follow incompatible blood transfusions.
- Mallory-Weiss syndrome	Vomiting of blood due to a mucosal tear of the gastroesophageal wall. Regarded as a result of vomiting.
- Mendelson's syndrome	An acute hemorrhagic pneumonia caused by the aspiration of gastric acid. Often a a complication of obstetrical anesthesia or of vomiting in the debilitated or immobilized patient.
- Reyes syndrome	A usually fatal syndrome in infants and young children consisting of hyperexcitability, seizures, hepatomegaly and hypoglycemia. At autopsy cerebral edema and a fatty liver are found.
- Sudden infant death syndrome	Syn: crib death, SIDS. Sudden death in apparently well infants, usually between the third and twelfth months of life, with negative or minimal autopsy findings.
Tamponade	See: Cardiac tamponade
Tandem bullet	A military type of ammunition in which two projectiles are placed in sequence in a single round. The tandem bullet is so designed that the two projectiles strike the target separated by a distance.

Tattoo	1. The introduction of insoluble pigments into the skin. Tattoos may be intentional for decorative or identification purposes or accidental. 2. Syn: powder stippling. An area of burned grains near the entrance wound of a bullet fired at close range.
T.H.C.	Tetrahydrocannabinol, a constituent of hashish and marijuana.
Temperature plateau	The period immeidately after death during which the internal body temperature does not fall. The temperature plateau may last 1-5 hours.
Temporary cavity	A momentary cavity created in the tissues by the rapid passage of a missile, causing much disruption. The size of the temporary cavity depends upon the energy of the missile and its rate of transfer to the tissues. The space remaining after the collapse of the temporary cavity is the permanent cavity.
Tentorium cerebelli	A fold of dura mater separating the cerebrum from the cerebellum.
Thallium	A metal, an ingredient of mouse and rat poisons. It is very toxic. Poisoning is characterized by neurological symptoms and loss of hair.
Thin layer chromatography	An analytic technique by which drugs may be separated by absorption chromatography on 0.5 mm thin sheets of absorbent. Extracted drugs are applied to the thin sheets along with drug standards and these drug mixtures are separated as they are moved along the thin sheet with an organic solution. Tentative identification is made by comparison with standards as well as observing the unique color of the drug which develops after spraying the separated drugs with specific color reagents.
Thrombosis	The formation or presence of a thrombus.
- coronary thromosis	Thrombosis narrowing or occluding the lumen of the coronary artery.

Thrombus	A solid, brittle coagulum formed in circulating blood in the blood vessels or chambers of the heart, its structure being largely determined by the turbulence of the blood. Its architecture thus differs from that of a clot.
- mural thrombus	A thrombus attached to the wall of a blood vessel or heart chamber.
Thyroid cartilage	The main cartilage of the larynx. It has two posterior projections on either side. The superior of these are frequently broken in cases of manual strangulation
Toxic	(Adj.) Pertaining to, caused by or acting as a poison.
Toxicology	The science of the nature of poisons, their effects and detection.
Toxin	A poisonous substance produced by bacteria, animals or plants.
Trachea	Syn: windpipe. A cartilagenous tube connecting the larynx with the bronchi.
Tracheostomy	Syn: tracheotomy. A surgical operation making an opening into the trachea in the neck to facilitate breathing.
Tranquilizer	A drug which sedates and reduces anxiety. The tranquilizers include the pheonthiazines, diazepines and butyrophenones.
Transsexualist	A person wishing to become a member of the opposite sex.
Transvestite	An individual obtaining sexual gratification by wearing the clothing of the opposite sex.
Trauma	A wound or injury.
- traumatic asphyxia	See: Asphyxia
Tuinal	Brand of secobarbital and amobarbital (Eli Lilly and Co.). Tuinal capsules syn: "double trouble," rainbows," tooies."
Ultraviolet spectroscopy (UV)	An absorption technique which allows identification of purified drugs in solution. Each drug molecule absorbs ultraviolet light in a relatively unique fashion and by comparing the pattern of absorption with a drug standard, the UV technique can be used to confirm the presence and quantity of a drug in a sample.

Ulcer	An open sore of skin or mucous membrane
Umbilical cord	A cord connecting the navel of the fetus with the placenta and containing two arteries and one vein.
Uterine tubes	See: Fallopian tubes.
Uterus	Syn: womb. A muscular hollow organ in the female in which the embryo develops.
Vagal inhibition	Syn: vagal reflex. Stoppage of the heartbeat through stimulation of the vagus nerve. Vagal inhibition may be caused by pressure upon the neck, immersion in cold water, minor surgical procedures, etc.
Vagina	The tubular musculofibrous passage in the female connecting the vulva with the cervix.
Vagus	The tenth cranial nerve originating in the brain stem, passing through the neck and chest and supplying branches to the larynx, heart, lungs, stomach and abdominal cavities.
Vein	A blood vessel carrying blood from the tissues to the heart.
Ventricles	1. The two lower, more muscular chambers of the heart. 2. Four intercommunicating cavities in the brain into which the cerebrospinal fluid is secreted.
Ventricular fibrillation	Irregular and ineffective contractions of the ventricles of the heart leading to sudden death.
Vernix caseosa	Syn: vernix. A greasy greyish-white substance derived largely from sebaceous glands covering the skin of the fetus.
Vesicle	See: Blister
Viability	As applied to a fetus, the stage of development at which it would be capable of extrauterine existence. Variously given as 20-24 weeks of gestation.

Vital	(Adj.) Characteristic of or essential of life.
- vital reaction	A reaction in a tissue, such as inflammation, occurring during life and thus used to distinguish antermortem from postmortem wounds.
- vital signs	Physical signs such as respiration and pulse, indicative of the presence of life.
Vulva	The external female sexual organs consisting of the vestibule, clitoris, labia majora and labia minora.
Wad	A disc of felt, cardboard or plastic used in shotgun ammunition.
- filler wad	Syn: spacer wad. A cardboard wad located between the overpowder and undershot wads.
- overpowder wad	Syn: base wad. A cardboard wad above the powder load of a shotgun shell.
- overshot wad	A thin cardboard wad above the shot held in position by the crimp. Not present in ammunition having a star crimp.
- plastic one-piece combination wad	In modern shotgun ammunition a single plastic wad located under the shot and taking the place of the filler wad.
Washerwoman's hands	A wrinkling of the skin of the hands and feet caused by prolonged exposure to moisture. It may occur before or after death.
Whiplash injury	An injury to the tissues of the neck caused by a sudden overextension of the cervical spine. It is common in rear end collisions. The injury usually involved the muscles and spinal ligaments, but in severe cases may damage the intervertebral discs, esophagus, trachea and sympathetic chain.
Widmark's equation	$A = p \times c \times r$ where A = total weight of alcohol in grams absorbed by the body. p = weight of subject in kilograms c = milligrams of alcohol per gram of whole blood r = ratio of alcohol absorbed by unit weight of whole blood (0.68 for men, 0.55 for women). Widmark's equation may be used to calculate

	the approximate alcohol levels produced by a known intake or the intake which corresponds to a known blood level, provided that the interval between the last drink and the taking of the sample is known.
Wiping	Syn: ring of dirt. Dirt and lubricant from the gun barrel and surface dirt from the bullet deposited on edges of a gunshot wound when there is no intermediate target. May be minimal or absent in non-lubricated ammunition (automatic or semi-automatic weapon).
Wound	An injury to the body caused by exterior violence.
- defense wound	A wound, usually on the fingers, hands or forearms of the victim of an attack, sustained while trying to grasp a weapon or ward off the assailant. The nature of the wound depends upon the weapons used for assault.
- penetrating wound	A wound which extends into an organ or tissue, having an entrance opening only.
- perforating wound	A wound which completely transverses an organ or tissue, having both an entrance and an exit opening.
X-rays, soft	Syn: Grenz rays. X-rays of lower voltage than those used for diagnostic purposes. Important use in identifying entrance gunshot wounds which may have small particles of metal present on clothing or skin.

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This compilation of legal citations dealing with medicolegal investigation systems and the role of the forensic pathologist is reprinted from the outstanding chapter entitled "Operational Aspects of Public Medicolegal Death Investigation," written by Drs. Charles S. Petty and William J. Curran in the book, Modern Legal Medicine, Psychiatry, and Forensic Science, by William J. Curran, A. Louis McGarry and Charles S. Petty (ed.), Charles C. Thomas, Springfield, Ill., 1980. The chapter presents an unusually well put together overview of modern medicolegal investigative systems, statutes, legal responsibilities, and potential liabilities. This bibliography is reprinted with the permission of the authors and publishers.

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FORENSIC ANTHROPOLOGY

By

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EXECUTIVE SUMMARY

Forensic anthropology is the application of selected scientifically derived and substantiated techniques of physical anthropology to matters of legal and public concern. The anthropologist may be consulted in homocide and assassination investigations, criminal and civil cases, burnings and mass disasters. Such consultation usually takes the form of identifying, or at least reconstructing, the biological nature of human remains that, due to extreme decomposition or fragmentation, are not recognizable or identifiable by methods generally used by other forensic scientists. Forensic anthropologists are able to reconstruct the biological nature of an individual from the skeleton, or sometimes parts of a skeleton, if the appropriate parts are present. They can determine sex, approximate stature at the time of death, and nutritional history for relatively complete skeletal remains. In many cases they can also determine the race, or major genetic population, to which the individual belonged. They can also estimate the approximate age at the time of death with varying degrees of accuracy and reliability depending upon the methods of estimation that are used. The forensic anthropologist is also able to determine whether skeletal remains are human or not, even if they are fragmentary, and can usually distinguish between prehistoric and forensic skeletal remains. The techniques of forensic anthropology can be applied with equal validity to skeletal remains within a few hours after burning, explosion, or fragmentation from other disasters or to those that may be several thousand years old. In many cases he or she can give estimates of the time since death based on the condition of the bones themselves. Occasionally it is possible to identify someone from a rather minute single fragment of bone.

Like many other biological and medical scientists, the forensic anthropologist often uses X-rays in making identification. In cases where antemortem X-rays are available, they can be compared with X-rays of the skeleton to achieve a positive identification based on similarities of internal bone structure developmental anomalies or unique configurations in the structure of the skeleton or parts of it that are included in medical radiographs. Such identification may involve the comparison of old healed fractures with medical or surgical descriptions, or more rarely, descriptions of pre-existing skeletal pathology. The forensic anthropologist is trained and experienced in identifying specific points of similarity in normal bone that would be unlikely to occur on the basis of chance alone.

Occasionally the forensic anthropologist will have photographs of a person missing or thought to be the deceased individual whose skeleton has been found. Such antemortem photographs of the face and head can often be compared with similarly oriented photographs of the skull in order to determine whether or not the contours of the skull could fit within the contours of the face and head as depicted in the photograph. This depends on a thorough knowledge of the variations in soft tissue thickness overlying different parts of the bony head and face. The greatest limitation to this method is usually not the condition of the remains as much as the distortion, foreshortening or angulation of the individual's face in most of the snapshots or portraits that are available for comparison.

Some anthropologists have become proficient in reconstructing the probable appearance of the individual during life from careful standardized techniques of adding known thickness from soft tissue to specific points on the skull and joining these with clay or plastilene to give an overall appearance of the skull plus soft tissue. The results of this technique

are often startling and enable the next of kin to recongnize the reconstruction; however, nearly half the time, the reconstruction may be of little or no help or even misleading. A few anthropologists reconstruct the probable appearance of an individual in drawings based on the appropriate contour and thickness of soft tissue overlying the skull. The possible advantage of this method is that it usually duplicates the direct head-on and side views of the police photographs of individuals who have been booked.. At its worst, the photographic method as applied to skeletal material for identification can provide general facial contours to the police artist or rule out the possibility that the skeleton in question could have been that of a particular individual.

Some forensic anthropologists have the capability of identifying blood type from blood, tissue, or in some cases both. By no means all forensic anthropologists maintain this capability, as the laboratory facilities, equipment and anti-serum needed for blood type determination are expensive to maintain unless used routinely. Those that do have the capability for determining blood type from blood, serum, dry blood or bone often go beyond the routine capabilities of many crime laboratories. Only a very few forensic anthropologists actually offer such a service, however.

A few forensic anthropologists have developed the capability of metric comparison of photographs of living individuals to determine whether they are photographs of the same individual or not. This involves the comparison of differences in shape of various anatomic structures within the head and face area. Although variations in camera, lighting, facial expression and angle of photograph make it very difficult many times to make a positive identification by this technique, it is often possible to absolutely exclude the possibility that two photographs are of the same person when they are of

people with subtle variations in anatomic structure who may none the less appear to look alike because of similarities in coloration, mannerisms of expression, and the like. This technique involves not only metric and ratio comparisons, but some statistical analysis of range of variability for one or more anatomic areas of the face.

A few forensic anthropologists have developed proficiency in identifying hand and foot prints. The majority who have become familiar with the geneticists' techniques of comparing dermatoglyphic patterns in finger, palm and foot prints can make quite positive identifications or completely eliminate the possibility of similarity based on ridge counts, triradia, crease patterns and general configuration of such prints. Much less commonly, some anthropologists can identify foot impression outlines when no dermatoglyphic pattern is present in the print. This is done by careful measurement and morphologic comparison of different areas and points in the outline print of the human foot, and is based on knowledge of variability derived from a data base of numerous such footprints made by different people.

The foregoing capabilities of forensic anthropology enable those skilled in such techniques to provide rather detailed biological descriptions of individuals from their decomposed, fragmented or incomplete remains, or from such traces of individuality as blood stains, hair, photographs or hand or foot prints. By using them, the forensic anthropologists can provide very significant information concerning an individual during life from an examination of such material not normally dealt with in the same manner by other forensic scientists.

CURRENT CAPABILITIES AND LIMITATIONS

During the course of their education, physical anthropologists study the basic aspects of other related disciplines, usually anatomy, osteology, genetics, zoology, and the effects of culture on human biology. In addition to the academic requirements, which usually include the PhD or Master of Science degree in physical anthropology, a forensic anthropologist must submit credentials for approval along with evidence of practical experience in the field before being permitted to take the qualifying examination for certification as a diplomate of the American Board of Forensic Anthropology. Such certification assures that those practicing in this very specialized field are both proficient and serious in their dedication to the use of their skills for the resolution of matters of legal and public interest, as previously described.

In addition to its specialized methods, the discipline has some special problems and limitations as well. The limitations include those of methodology, such as the need for considerable experience in race determination, for example, and the limitations of the skeletal material itself. Other limitations result from variations in education, training and experience among the practitioners, some of whom may be well known as physical anthropologists but may have little or no experience in osteology or forensic work.

Budgetary constraints often limit the equipment a laboratory can afford and even limit the size of the lab itself. It is expensive to equip even a simple laboratory, to maintain a current supply of the more exotic blood antisera, or to keep an X-ray machine in operation. The relatively small volume of forensic cases most forensic anthropology laboratories handle keeps

many of them from maintaining complete capability in all areas.

Outside of the military, most forensic anthropologists devote a rather small percentage of their time to actual forensic work. Most are actively engaged in teaching and/or research at a university or museum, where the majority of their time - and budgets - are devoted to non-forensic activities. In addition, departmental policies may limit the topics of research and the salaries of laboratory assistants to other non-forensic pursuits. In the case of military identification teams, heavy caseloads generally preclude much research time.

Skeletal Identification

The ability to determine whether a skeleton or parts of it are human or not depends greatly on the training and experience of the examiner. In living individuals, most people can distinguish cows from deer, pigs from sheep, or gorillas from humans. If only the skeleton is present, and particularly if the skull is missing, this may be much more difficult for most laymen to do. Most forensic anthropologists have worked extensively with human skeletal remains and are able to distinguish human from non-human even from only one bone or part of a bone. A few, who have worked with skeletal material from archeological sites, can also identify the zoological family of non-human skeletal remains.

Age at Death

The approximate age of an individual at the time of death is important data for identification, as it eliminates a large segment of the population as belonging to the skeletal remains in question. The narrower the range of the anthropologist's estimate, the more useful the estimate is, provided

the actual age is within the range of the estimate.

Accuracy is the specificity with which age, or any other factor, can be estimated. That is, the narrower the range of the estimated age, the more accurate it is if the actual age is somewhere within the range of the estimate. Reliability, on the other hand, refers to the number of times the actual age might fall within the range of the estimate. One might estimate the age at the time of death of a skeleton as between birth and 95 years of age and be close to 100 percent reliability. On the other hand, such information is of little value in identifying an individual skeleton, as it covers 99 percent of all living humans. A range of ±3 years for an estimated age at the time of death is quite accurate, or at least may be, in that it eliminates a large segment of the population and focuses attention on a rather small segment. In the hands of an experienced forensic anthropologist, an estimate based on epiphyseal closure in combination with dental eruption in a child or early adolescent with a range of ±1 year would have a reliability approaching 75 percent. An estimated age with a range of ±1 year for a skeleton over 40 years of age, while focusing on a small segment of the population, would have a very low degree of reliability (depending upon the methods of age estimation used) and might actually be misleading

As with any other method used in identification for legal purposes, the appropriateness of the method used is a highly significant factor. It would be totally inappropriate to estimate the age of someone who had died in his 60's by epiphyseal closure, as all epiphyses in the body are closed by age 30. Likewise, in dealing with the remains of children, it would be inappropriate to rely solely on microscopic age estimation unless no teeth were present and only parts of the shafts of long bones were available for examination. The reason is that dental eruption and epiphyseal

fusion afford a much narrower range of accuracy in childhood and adolescence than the ±5 years provided by the microscopic method.

The following Table indicates different methods of determining age and their aproximate range of usefulness.

TABLE I

DETERMINATION OF AGE

Ossification Centers	Fetal - 18
Size of Bones	Fetal - 15
Dentition	Fetal - 23
Epiphyseal Fusion	14-30
Basilar Suture	14-20
Pubic Symphysis	18-40
Vertebral Exostoses	Adult
Peri-articular Margins	Adult
Cancellous Regression	Adult
Microscopic Examination	Birth - 95

In the estimation of age at the time of death, it is particularly important that the most appropriate methods of estimation are used for the age range of the skeleton and the material that is available for examination. The combination of accuracy and reliability determine the usefulness of a method and the confidence with which it can be applied. The most useful age estimates will usually be expressed in terms of plus or minus a given number of years, depending on the age of the individual at death and the method used. An experienced forensic anthropologist will discuss the reliability and limits of confidence of the methods that are applied.

Determination of Sex

The sex of a skeleton is one of the easier determinations to make in most cases for anyone with training and experience in anatomy, anthropology or medicine. Unlike the estimation of age, sex is an either/or determination. There is no range of accuracy. People are classified as either male or female, although there is some variability in the degree to which each person's skeleton exhibits the skeletal characteristics of either sex. Consequently, reliability does remain a factor in sex determination. The reliability of sex determination by an experienced examiner is around 90 percent. The reliability of some of the multivariate analytical methods has been statistically determined to be between 90 and 95 percent, and it seems probable that there is an overlap of 5 to 10 percent between the se s for any skeletal sex traits. That is, between 5 and 10 percent of th population do not exhibit the skeletal manifestations associated with their sex to a degree that clearly distinguishes sex by skeletal differences. Reliability is affected, naturally, by the parts of the skeleton available for examination and their condition. Badly fragmented or eroded bones, or a skeleton missing the most informative parts, may be difficult to sex.

The most reliable areas of the skeleton for determining sex are in the vicinity of the pelvis. The area of the pubic symphysis is particularly useful. Various authors, including Phenice, Krogman and Stewart, have summarized the differences in the pelvis that enable one to determine sex, and most have mentioned those in the symphysial area. The methods described by Phenice were checked against known-sex pelves and proved to have a high degree of reliability. Unfortunately, the synphysial area is not always intact in skeletal remains because of burning, erosion, fragmentation or missing parts.

There have been methods of sex determination based on measurement and discriminant function analysis as well. Those devised by Thieme and Schull and Steele are particularly useful in cases where the symphysis or other parts of the pelvis are damaged because they rely on femoral or humeral head diameter or on measurements of specific bones, such as the calcaneus, which might not be affected when the pelvis is destroyed. These metric methods are particularly useful for forensic anthropologists starting in the field with relatively little experience in that they provide known reliability from the utilization of easily made standardized measurements.

Sex differences in the skull enable forensic anthropologists to determine sex in the absence of sufficient postcranial remains. These are based on the observation that males tend to have larger brow ridges and mastoid processes than females and that the mandible in the area of the chin is deeper in males than in females. Sex determination of the skull tends to be more subjective than from the pelvis and somewhat less reliable, unless discriminant function analysis is used in known race material. (See Giles and Elliott, 1963). The following Table lists skeletal areasused in sex determination in adults. The determination of sex in children under the age of puberty is more difficult and less reliable.

TABLE II

SEX DETERMINANT SKELETAL AREAS

Pelvis	General shape
	Ischio-pubic
	Pubic symphysis
	Sciatic notch
Skull	Brow ridges
	Mastoid processes
	Multivariate
	Frontal eminences

TABLE II (cont)

SEX DETERMINANT SKELETAL AREAS

Long Bones	Femoral head
	Humeral head
Other	Sternum
	Sacrum
	Calcaneus

Determination of Race

As with sex, the determination of race is a specific determination. The examiner is either right or wrong in assessing the major genetic population to which a skeleton belongs. Such determinations are based on the appearance of the anatomic structures of the face, particularly those surrounding the nasal and oral area. The shape of the nasal aperture, type of nasal bridge, configuration of the lower nasal borders, and type and degree of prognathism are probably the best indicators of race, although hair form, cheek bones, palate shape, teeth and femoral bowing are also indicative.

Virtually no forensic scientists other than anthropologists have any training or expertise in the determination of race. To a large extent such determinations are based upon personal experience in viewing skeletal remains of known race on the part of the examiner as much as training or vigorous methodology. For this reason the reliability with which various forensic anthropologists can determine race varies somewhat. It should be emphasized that the youth or age of the examiner is of little consequence when compared to the number of skeletons of known race he or she has actually examined.

Although the most reliable criteria for determining race are found in the skull, there are other indications of race that have been reported by various investigators. Giles and Elliot have reported on discriminant function in determination of race based largely on specific measurement of the skull. This method is quite effective when dealing with relatively complete skulls of known sex. However, when only postcranial remains are present the problem is more difficult. The relative lengths of the bones of the lower segments of the arms and legs compared to the upper segments of the same extremities afford reliable indicators of race, particularly in combination with the anterior bowing of the femurs. Steele has reported some racial variations in the shape of the bones of the foot and ankle in multivariate analyses. All of these may prove useful in cases where the determination of race is not clear-cut or the skull is not present.

The determination of race is not simple. It is complicated by the broad range of variability for any particular characteristic, the sizeable overlap among the different major races with regard to a characteristic and the fact that individuals may be listed as members of one racial population for sociologic reasons, when in fact biologically they are much closer to another population. Even so, experienced forensic anthropologists can determine race with impressive reliability. In addition to the skeleton, any head hair present can be quite useful in race determination, as can certain blood factors, although blood sufficiently well preserved for such analysis is extremely rare in primarily skeletal remains.

Determination of Stature At Time of Death

It is important to bear in mind that stature at the time of death may be somewhat different from the last recorded height of an individual.

That is particularly true when dealing with the skeletal remains of realtively young individuals, whose stature may have been recorded at the age of 16 or 17 and several years prior to death. Subsequent growth will naturally affect the accuracy with which stature can be estimated. Generally speaking, the estimation stature is based upon the observation that the lengths of the major long bones of the extremities bear a constant relationship to the actual stature of the individual at the time of death. Trotter and Gleser have reported the most satisfactory method for stature estimation based on the lengths of the long bones. Utilizing data collected on skeletons of young adult males from World War II and the Korean War, the tables that they offer provide estimates that are within ±1 inch of the actual stature at the time of death 50 percent of the time, ±2 inches 75 percent of the time, and ±3 inches over 95 percent of the time. Understanding the limits of reliability for each of these ranges of estimate is important in interpreting the probability that a skeleton belongs to a specific individual. Stature determination, or estimation actually, is one of the easy, straightforward estimations in forensic identification, because it requires only simple standardized measurement and recourse to stature-estimating tables provided by Trotter and Gleser.

In some cases of identification, the skeleton is badly fragmented and parts of major long bones may be missing. Steele has provided regression formulae for estimating stature at the time of death from segments of the major long bones of the extremities. His formulae are particularly useful in high speed impact accidents such as aircraft crashes. Stewart provides an excellent summary of the above-mentioned methods of stature estimation as well as that of Fully and Pineau, which includes the estimation of stature from measurement of the vertebral column.

Commingling

Not infrequently the skeletal remains of two or more individuals are mixed together when they are recovered. When this occurs, it is necessary to separate the skeletons into individuals. Keeping in mind the location of the major skeletal remains, the forensic anthropologist usually begins with a skull and articulates the bones down through the spinal column to the pelvis, legs and feet. It is, of course, obvious in cases of duplication of skeletal parts that some bones must be removed from the primary skeleton of the individual. When this is necessary, the anthropologist removes those bones which obviously do not belong to the primary skeleton from which he was working. The decision for this is usually based on variations in length, age, muscularity, and general configuration. When commingled remains have been separated into two or more individuals, the task remains of identifying each of them. Often the identification of one skeleton may enhance identifying other passengers of automobiles, aircraft, boats or the like. Not infrequently when police seach an area and recover skeletal remains, portions of non-human remains are commingled with the human bones. The forensic anthropologist is usually well trained and experienced in identifying human material and can readily recognize non-human commingled remains.

Forensic anthropologists may be extremely useful in identifying and separating commingled remains from mass disasters, such as air crashes, explosions and other catastrophes that badly fragment human bodies, even though the remains are not strictly skeletal.

Wounds and Skeletal Pathology

In the course of training and the practice of forensic anthropology,

most forensic anthropologists gain experience in recognizing wounds in completely skeletal remains. This applies not only to wounds that occur at the time of death, such as gunshot wounds, fractures or stab wounds, but also to healing fractures or gunshot wounds. In some cases, certain forensic anthropologists have had extensive experience in examining the remains of individuals who have died of such wounds. While it is entirely possible for someone to die of gunshot, stabbing, or other injuries without any indication in the skeleton of what has happened, it is not unusual for bones to be chipped, cut or fractured by these injuries. The forensic anthropologist can usually determine the nature of the wound and whether it occurred at, before or after the time of death. He may be less inclined to state unequivocally that a given wound was the cause of death, as this is the province of the forensic pathologist. It may often be obvious to a court, however, that massive fracturing of the skull, gunshot wound through the brain cage or decapitation would inevitably result in death.

The ability to recognize preexisting pathology in the living individual's skeleton from an examination of the dry skeleton varies considerably from one forensic anthropologist to another, depending upon their individual experience in examining skeletons with known, documented pathological lesions. Most forensic anthropologists can recognize healed fractures, arthritis, and other skeletal manifestations of the most common injuries of bone. Not all can distinguish inflammation from skeletal repair or injury or the more subtle forms of skeletal pathology. Radiographs are extremely useful in the interpretation of any skeletal lesions and not all forensic anthropologists have access to X-ray equipment, although many are able to interpret radiographs.

Time of Death

The time of death is one of the most difficult and unreliable estimations that forensic scientists are called upon to make. If more than a few days, or even hours in some cases, have elapsed, variations in exposure, temperature, physical condition and immediate environment may produce widely varied results that are difficult to interpret - especially if a knowledge of the circumstances of recovery is not available to the examiner. The more time that has elapsed since death, generally, the wider the margin of error tends to be. While the medical examiner may estimate the time since death in hours in recently deceased individuals, it would be hazardous to estimate even the number of days in skeletalized remains that have been buried or lying exposed for several months. When remains have been recovered several years after death, it may be problematic to speak of the time that has elapsed in terms of months or even years. When dealing with truly large periods of time, as the anthropologist often does with archeologic remains, $\pm$100 years may be an unrealistically narrow range of accuracy. Nonetheless, many forensic anthropologists have developed a feeling for time since death that is based mostly on years of experience in dealing with such cases.

When skeletal remains are found, law enforcement officials are interested primarily in how long the person has been dead in order to determine if a possible crime occurred within the statute of limitations. One important function the forensic anthropologist provides is distinguishing between remains of prehistoric Indians or early settlers and those that might be victims of more recent crime. In general, any odor emanating from the skeleton and the preservation of dried soft tissue, blood vessels in the bone (which are often detectable by magnified examination) or ligaments are

indications that death occurred fairly recently. On the other hand, weather flaking of the outer part of the bone, erosion or bacterial absorption of bone, and internal staining by ground water or mineralization of the interstices of bone indicate that the person has been dead a considerable period of time, possibly hundreds of years. The confidence of the individual examiner may depend upon his or her experience in seeing skeletal material that has been buried or exposed under a variety of conditions for varying periods of time. Virtually every forensic anthropologist will freely express his or her confidence in the estimates provided.

In addition to the above indications of time since death, it is possible occasionally to identify skeletal remains with particular archeologic populations on the basis of cultural practices or burial inclusions, thereby saving the police hours of fruitless effort searching for the identity of a possible "homocide victim."

Personal Identification

Physical anthropologists, often working with artists, have been reconstructing the probable appearance of individuals during life from skulls for several decades. In the past, the results were mixed and often misleading, in large part due to the lack of an appropriate and adequate data base. Generally, reconstruction then was based on applying the appropriate thickness of tissue over specific areas of the skull where the soft tissue thickness had been documented. In its plastic form, the skull, or a model of it, had specific thickness dots of clay or plasteline applied to specific anatomic areas. These were then connected by ribbons of clay or plasteline until the intervening spaces were filled in.

Unfortunately, data from European cadavers were more often than not misleading for the polygenetic American population, and little research had been done on soft tissue thickness for American blacks or other non-white populations.

Recent additions to our bank of knowledge concerning soft tissue thickness over specific landmarks on human skulls have made it possible for reconstruction of probable appearance during life to be more useful than it has been in the past. In part, physical anthropologists have acquired a keener understanding of the range of variation in tissue thickness for specific parts of the skull. Some anthropologists prefer to use drawings based on specific soft tissue thickness measurements in the anterior and lateral views rather than reconstructing the appearance in clay or other plastic media. As an artist or anatomist might look at a living individual's face and ascertain the bony framework underlying skin and muscle, the forensic anthropologist reverses the procedure and starts with the bony framework adding muscle and soft tissue in either plastic or graphic form. The results are often spectacular, enabling the next of kin to recognize an individual immediately, but may also be misleading. There is tremendous variation in the thickness of soft tissue overlying the parts of the face and head most often utilized to visually recognize someone. In particular, there is a large difference in lip thickness between races. Therefore, the probable race of the individual must be known to reconstruct the appearance during life with any degree of accuracy.

Other areas that make facial reconstruction difficult include facial expression, eye color, and hair color and style that give individuals their individuality. Shape of ear, flair of nostril, and hair line are virtually impossible to determine from a dry skull. Yet, these are overwhelming factors in recognition of individuals, as are mannerisms, such as how the

mouth was held in repose and characteristic tilt of the head. When the most individual characteristics cannot be seen, it is often difficult for even the next of kin to recognize an individual from the remaining valid but often ignored minutia of appearance. That is true also of the living and forms the basis for masking particular parts of the face to avoid recognition.

Those forensic anthropologists who have developed sufficient skill in facial reconstruction to enjoy a fairly high "batting average" are generally the ones who utilize this technique most frequently. While their overall reliability is about 50 percent for such identification by recognition, some have a good bit higher level of success in facial reconstruction.

An imaginative, though nonscientific, laboratory officer once actually suggested that the best way to assure identification of all deceased military personnel was to have each soldier's serial number tatooed on the bone of his forehead, so that when he died and the remains were recovered years later, he could be identified by the visible serial number. Had he been aware of radio-opaque dyes at the time, he might well have suggested that people could be identified by X-raying the frontal bone and reading such tatooed numbers. From the standpoint of identification, that would certainly simplify the identification of remains which have managed to "keep their heads" after death. Even that, however, like most panaceas, would not solve all problems of identification. At the operation end of tatooing numbers into the bone, the problems would be considerably greater, and recruiting officers would probably have to attain new heights of inducement to off-set the possible reluctance of recruits to have their bones tatooed.

What we need then, are identifying marks in the skeleton that can be observed during life that are as specific and individual as a serial number. Fortunately, such marks do exist in the skeleton, but they can only be viewed

in the living by X-ray. The limitations are seldom those of the internal markings of bone themselves, but rather the relative rarity of having ante-mortem radiographs of the specific areas available. When such ante-mortem radiographs are available, the anthropologist X-rays the remains in the same position or view so he or she can compare specific marks of individuation inside the bone. Among the best areas for this are the frontal sinuses of the skull and the pattern of the mastoid air cells. There are sufficient numbers of variables in each of these areas to make the probability of two individuals having exactly duplicate patterns astronomically low. It is probable that anywhere in the skeleton that one can find radiographs of sufficiently high resolution to delineate clearly the pattern of cancellous bone, one can make or exclude identification positively by painstaking comparison of the minutia of patterns. Radiographic identification of this sort in the hands of an experienced expert can be even more positive identification than fingerprint analysis. Of course anomalies of bone that were detected during life can usually be observed in the skeleton or in skeletal radiographs.

It is quite possible that in the near future forensic anthropologists will develop facial feature overlays to reconstruct the probable appearance of an individual during life from measurements of the skull and face. Such aids could provide, as do the Identi-kits currently used by police artists, general face contours, hair lines and various features such as eyebrows, noses and mouths. The difference would be that the anthropological overlays would be based on variations in soft tissue thickness within known ranges for specific landmarks of the face and skull. These scientifically derived facial outlines could then be tried with a variety of eye, nose, ear and lip forms to produce the most probable appearance of the living individual. Such kits would be based on algorithmic programs that will probably have to be computer generated.

Serology

Most forensic anthropologists who have had any training or experience in human genetics have the ability to type freshly drawn blood for a variety of factors. Those who maintain the capability by stocking a supply of antiserum can determine in fresh samples variations in the ABO system, whether one is a sub-one or sub-two type and whether one is type M, N or MN as well as the Rh type and such esoteric factors as Kell, Lutheran or Duffy. This information along with data derived from a battery of measurements of individuals and dermatoglyphics often permits an anthropologist to determine that two individuals are, might be, or cannot be related. For this reason, physical anthropologists have often gotten involved in paternity testing and in trying to determine whether long-separated individuals are members of the same immediate family. One blood factor, the Diego factor, is quite helpful in determining genetic population affinities, as it originated apparently in the Northern part of South America and spread in American Indian populations from there.

Forensic anthropologists with serological capability are usually able to type fresh tissue or dry blood stains for ABO and MNS as well. A few have developed skill in the techniques of determining blood types from dry bone, although the reliability of this procedure has been called into question at least once (Thieme and Otten). Essentially, the technique is the reverse of regular blood typing in that the known whole blood is used in different titration, or dilutions, as an antiserum against which the presumed agglutinin in a "soup" made of the pulverized cancellous bone of an unknown skeleton is used. The reliability of the results vary and are best interpreted for specific cases by the individual forensic anthropologist doing the blood type analysis.

Hair Examination

There is such a wide range of variability for any single measurement or factor in human hair that most forensic anthropologists do not attempt to determine whether two hairs came from the same individual. In a group of 25 hairs from the same head, one might find a variety of scale pattern, medullation and pigmentation. Therefore, most forensic anthropologists examine hair either grossly or microscopically for the purpose of determining major genetic population only. The head hair of caucasoid individuals is quite variable, ranging from straight to curly, coarse to fine in texture and white to extremely dark in color. There appears to be less variability in the head hair of Negroids, or Mongoloids. Mongoloid hair tends to be quite straight and of large diameter as compared to the other two racial groups. Negroid and Australoid hair tends to be tightly curled or deeply waved and dark in pigmentation.

These variations are reflected in microscopic examination of hair also. The hair of Negroids tends to be oval, that of Mongolois, quite round and larger in diameter, while that of Caucasoids, although variable, is generally oval in shape. There are also variations in the cross-section index of width divided by length and the area of the cross section that can be helpful in determining race. (See Kerley and Rosen, 1973).

The gross of microscopic appearance of head hair is a fairly reliable indicator of racial affinity in the United States, although it should be borne in mind that there is a tremendous overlap among individuals of all races for any single characteristic.

Photographic Identification

The forensic anthropologist is often called upon to determine whether

two photographs are of the same individual. These may be photographs thought to be of one individual taken at different ages, photographs of criminals taken by police to be compared with those taken at the scene of a crime, or photographs of a cadaver compared with those taken of an individual during life. The anthropologist is uniquely well prepared to deal with such comparisons as he or she has been trained in the measurement of specific landmarks overlying bony anatomic features in the face and skull. Such anthropological comparisons are usually made when recognition is not positive or when visual recognition of a photograph is questioned, as may be the case with photographs taken at the scene of a crime or other event in which identities are not known.

Such comparisons are based on distances measured between specific anatomic landmarks visible in the photographs and the ratios of their distances. That is, the relative width of different parts of the face versus lengths are computed for both sets of photographs and then compared mathematically. Obviously, it is helpful when both photographs to be compared are taken in similar planes, as variations in the angle of the face to the camera, in the level of the camera to the face, and in lighting can make it difficult to interpret anatomic landmarks similar in both photographs. Whereas the photographer or artist might measure the distances between eyes and nose, nose and lips, and length of face, the anthropologist goes on to determine the ratios between width of cheeks to length of face, length of upper face to lower face, length of mouth to chin versus nose to chin, and the like. As with trying to establish whether the shape of a skull is compatible with a person's photograph, it usually connot be stated with certainty that two photographs are of the same person;

rather it may be stated that two photographs cannot be of the same person because of differences in the anatomic structure of the head and face. Unless both photographs are posed for the purpose, considerable caution must be used in interpreting even metric comparisons, particularly when the photographs have been taken several years apart. The most obvious variations are in recession of hair lines and the effects of weight loss or gain.

Aside from the flat denial that two photographs belong to the same individual, the forensic anthropologist usually talks about the probability that the photograph in question are of the same individual. This can be done with varying degrees of confidence depending on the nature of the photographs themselves. Part of the problem at present is that there is no adequate data base to which the forensic anthropologist can refer to establish the statistical probability that two look-alike individuals could have virtually identical anatomic ratios on the basis of chance alone. The anthropologist can usually speak with more confidence in stating that a given photograph matched another in a limited series, not excluding the possibility that somewhere on the face of the earth another individual might have identical measurements.

Foot and Hand Print Impression and Comparison

Geneticists and physical anthropologists usually go beyond the comparative analysis of fingerprint experts in recording dermatoglyphic patterns of ridges in the traction areas of the hands and feet. That is, they analyze not only fingerprints but also prints of the palm and foot. This is done not only in terms of configuration type, i.e., whorl, loop, arch or mixed patterns of the finger and toe prints but also in terms of the various triradii of the

palms and soles. They generally do this to assist in estimating the degree of relationship among various individuals and to distinguish identical from fraternal twins. As with ridge count, configuration and pattern analysis of finger prints, they are also capable of making comparisons for purposes of identification. Whenever sufficient skin is present in recent remains, the forensic anthropologist will inflate the finger pads and make prints of not only fingers but also palms for subsequent comparisons with pre-existing files, should they exist.

Robbins has described a method for the identification of footprints even in the absence of ridge patterns from analysis of the outline of the foot impression. Working with the outline left by the foot Robbins uses some 70 observations and measurements in combination to determine individuality of footprints. These include measurements on a special grid taken between specific landmarks of the foot outline as well as nonmetric observations as to the shape of impressions left by the toes and specific parts of the foot. She has collected a data base of known footprints of over a thousand people to establish the probability that two prints could have occurred on the basis of chance alone from different individuals. Her evidence has been admitted into court in California and other states. This method enables her to trace the trail of one individual out of several through a pattern of prints as well as to establish identity for the individual prints.

Using all of the methods briefly outlined above, the forensic anthropologist can provide a very specific biological description of an individual from a combination of his or her skeleton, hair, blood type, photographs, radiographs or hand or foot prints. The problem here is to match such specific information

with that available in the files of missing or deceased persons for selection and comparison for purposes of identification. Usually the anthropologist can be considerably more specific about the biological nature of the individual than the information that is available for comparison. Because the information recorded for identification in the living is based on visible soft parts, eye color, hair color, and so on, the information the anthropologist provides from the skeleton must be in similar terms, although the skeleton itself could provide much more specific information. Still in all, the forensic anthropologist is able to provide identifying data in a suprisingly high percentage in the cases attempted and information concerning the circumstances pertaining to the time of death and even afterward in many cases as well. Where antemortem photographs, radiographs or medical records are available, the forensic anthropologist can often provide positive identification by comparing these with the skeleton in question.

DEVELOPING AREAS

The traditional methods of determining age, sex and race are constantly being improved and expanded by new research approaches and increased use of computer statistics. The newer approaches tend to rely more on hard scientific data and analysis and less on "art" or "skill," although experience still remains very important in these areas.

The estimation of age at the time of death has been extended to cover the range of birth to 95 by the counting of microscopic structures in human long bones, mostly of the leg. The method provides a reliability of over 87 percent for a range of accuracy of ±5 years (See Kerley, 1965 and 1970). More refined statistical analyses (Bouvier and Ubelaker, 1977; Kerley and Ubelaker, 1978) permit the adjustment of greater reliability for a wider range of accuracy.

Racemization of collagen in bone, or aspartic acid in teeth, is a promising recent method of estimating the age at death, although it is complicated and requires rather sophisticated and expensive equipment to perform.

The determination of sex and race has been enhanced recently by several statistical studies involving measurement of the skull and other bones followed by discriminant function analysis and the establishment of published sectioning points that divide the populations in question. These have the advantage of affording simple methods of measurement that can be given a statistical decision as to population (sex or race) by someone with relatively little experience.

The determination of time that has elapsed since death is still an

elusive estimation. Carbon 14 and other radioactive methods allow very broad estimates for pre-historic specimens, but cannot be useful in much of forensic work. Racemization and other complicated chemical procedures may offer some promise, but the variability of postmortem conditions of soil and exposure make specific estimates of time since death problematic.

Personal identification, either by photographic or foot outline measurement, requires a set of adequate data banks against which to compare measurements of current samples in question in order to determine the probability of duplication on the basis of random chance similarity of strucutre. These data banks are currently being collected and expanded by individuals active in such methodology. All measurements that can be made of any object are not equally sifnificant, and the selection of definitive measurements will require statistical analysis of adequate data banks.

There have been some advances in the training of forensic anthropologists in the past few years in that several universities offer courses oriented specifically toward the collection, presentation and interpretation of information in legal cases. Even so, many practicing forensic anthropologists have individual specializations that they pass along to their students and in which other anthropologists get little practical experience. The result of this is that there are some 50 forensic anthropologists available for legal case consultation who have varying degrees of ability in sub-specialty areas.

CRITICAL ISSUES

As pointed out, the formal education of physical anthropologists is generally adequate, if a little uneven. This is not yet true of specific training in forensic anthropology, although there is a current trend toward the standardization of courses in that area. Most physical anthropologists who specialize in forensic work have had courses in anatomy or osteology and have learned the basic techniques of age, sex and race determination. Fewer have had formal courses at the university level in the application of these techniques in forensic cases. Laboratory training and experience in some of the less common procedures varies among forensic anthropologists a good bit. To some extent this is alleviated by participation in the scientific sessions on the topic at annual meetings of the American Academy of Forensic Sciences or the American Anthropological Association or by attendance at one of the various seminars on the forensic sciences that are given from time to time. Reading books and articles on the subject have helped to disseminate knowledge of the most recent methodology as well.

The introduction of a certification program through the American Board of Forensic Anthropology has been most beneficial in elevating the minimal standards of practice. The problem of periodic recertification to ensure current proficiency among diplomates is a matter before the Board of Directors at present, and it is probable that some form of recertification will be adopted in the future.

Actual physical laboratory facilities remain a rather critical issue also. Although a large table in a well-lit area is sufficient for the gross

visual examination of an anatomically laid out skeleton, adequate space is not always available in anthropology departments, and even standard anthropometric instruments may be scarce. X-ray and bone sectioning machines are almost luxury laboratory items, and many labs do not even have microscopes. In some cases, nearby medical facilities can be used, however. Such special equipment as spectrometers and electrophoresis apparatus are found in only a few forensic anthropology laboratories, but as most practitioners are at universities, equipment in other departments is often available.

Two other problems exist. One is the lack of awareness of forensic anthropology on the part of its users. The other is the lack of information available in most cases concerning the details of body recovery and follow-up information once a case has been resolved. Physical anthropologists who are accustomed to working with prehistoric remains that have been carefully documented as to location by surveying techniques and depth measurement in meter-square grids are sometimes frustrated by working with a couple of boxes of the jumbled bones of two or more individuals in the absence of any real knowledge of their relationships when found. It is hopeful that the inclusion of details of the archeological methods of recovery will be helpful in the future at seminars for police crime scene investigators.

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GLOSSARY

ABO	First discovered blood type system. Type A, AB, B or O.
Accuracy	The range of, or precision with which, an estimate can be made with acceptable reliability.
Antiserum	A blood serum that is used to agglutinate cells of a specific type for blood typing.
Bacterial resorption	The leaching away of microscopic areas of bone in globular fashion by bacteria after death.
Basilar suture	A suture line where growth occurs at the base of the skull between sphenoid and occipital.
Calcaneus	The large bone of the heel.
Cancellous	The fine spongy netwoek of bone inside the vertebrae and ends of long bones.
Dermatoglyphic	Pertaining to the traction ridges on the skin of the fingers, toes, hands and feet.
Determination	The decision that a bone or skeleton belongs to one specific group or population.
Diego	A blood factor found in highest frequency in the natives of Northern South America and in diminishing frequency away from the area.
Discriminant Function	A statistical analysis that provides a formula combining several measurements that best discriminate between two or more populations.
Duffy	One of several blood factors for which one can be either positive or negative.
Epiphysis	A bony cap that forms the end of a long bone and fuses to the rest of it during adolescence.
Estimate	Usually a range mathematically provided that encompasses the probable age, stature, etc.
Femoral	Pertaining to the large bone of the thigh.
Femur	The thigh bone.
Frontal sinus	A fan-shpaed hollow inside the frontal bone above the nose that tends to be distinctive in each person.

Humeral	Pertaining to the large bone of the upper arm.
Humerus	The bone of the upper arm.
Identi-kit	A series of transparent drawings of parts of the face that can be used to build up the facial appearances of suspects or deceased.
Ischio-pubis	An index devised by Washburn to discriminate, along with the sciatic notch, between male and female pelves.
Kell	One of several blood factors for which one can be either positive or negative.
Landmark	An easily located spot from which measurements are made on the skull, face or body.
Lutheran	One of several blood factors for which one can be either positive or negative.
Mastoids	Bony projections just behind the ears that have complex and distinctive air cell patterns.
Medulla	A tubular hollow running part of the length of a bone or hair.
MNS	A system of blood types. One can be M, MN or N.
Multivariate Analysis	The statistical analysis of relationship among several variables.
Ossification	The development of bone. The appearance of ossification centers is a basis for age estimation.
Osteology	The study of the skeletal system.
Overlay	The transilluminated inspection of two photographs or radiographs simultaneously in register.
Palmar	Referring to the palm of the hand.
Plantar	Referring to the sole of the foot.
Plastilene	(or Plasticene) commercially available plastic modeling media similar to clay.

Postmortem erosion	The destruction or wearing away of delicate parts of a bone as a result of ground acidity, larval destruction or other factors of burial or exposure.
Prognathism	The forward projection of the middle or lower part of the face.
Pubic symphysis	The area where the two halves of the pelvis come together in the front.
Racemization	Changing from an active to an inactive state usually over a period of time.
Regression	(1) Gradual loss of something, i.e. bone as the cancellous bone withdraws up the bone end. (2) Statistically derived formula for determining one quantity from another.
Reliability	The predictability with which an estimate or determination will match the actual (age, sex, race, stature, etc.).
Repeatability	How often the same investigator can produce the same result using the same method.
Rh	The Rhesus factor in blood; actually three or more blood types described either as Rh-Hr or CDE systems.
Sacrum	The spade-shaped bone that forms the back of the pelvis below the small of the back.
Sciatic Notch	A large V-shaped notch toward the rear of each innominate (pelvic) bone which is narrow in males.
Sternum	The breast bone, to which the ribs attach in front.
Secretor	One who secretes blood type A or B antibodies in most body fluids.
Taphonomy	A study of the events that affect a body after death.
Trabecular	Refers to the spongy cancellous bone of the vertebrae, long bone ends, pelvis, etc.
Triradius	The point where three dermatoglyphic lines all come together.
Vertebral Exostosis	Bony outgrowths on the bodies of vertebrae that occur and increase with advancing age.

CONTINUED

3 OF 5

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FORENSIC DOCUMENT EXAMINATION

By

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EXECUTIVE SUMMARY

Too often document examination is described in the narrow confines of handwriting and checks. The following offers an opportunity to correct this impression by presenting the various subject areas of the discipline, within which are discussed some of the problems encountered, the possibilities and reasons for identification, and the limitations within which the competent examiner works. It will be seen that the document study involves the varied means of placing a message upon a piece of paper, in addition to paper itself. Those areas of document examination where technology has recently presented entirely new challenges as well as established document problems which are being better resolved because of new techniques are highlighted.

The credentials of the document examiner and their program of certification are reviewed in some detail because there is often misunderstanding as to the accepted standards of education, training, experience and achievement of the qualified examiner of questioned documents. Several other issues important to a better understanding of our profession are cited.

Definition and Scope of the Field

Documents are a written means of communication between people, a method of record keeping and instruments of legal intent. They may represent the thoughts of people, provide instruction, safeguard information or bind a person to his word. Out of the millions of documents which are generated each day, only a handful of these will, at one time or another, cause suspicion or inquiry. The documents may be of a social, business or legal nature. In some way, however, they are the product of and represent the

interests of a person.

It is those documents that cause suspicion or inquiry that the document examiner will be called upon to investigate. Some documents will not necessarily show obvious signs of tampering, and some will be found to be perfectly valid; the circumstances of the case will dictate the instances when such an examination should be sought to resolve the validity or authorship of a document.

Document examination involves the critical examination of documents for the purposes of determining; the authorship of a document, whether a relationship exists between two or more items, whether or not a document is what it purports to be, and whether or not a document has been altered. These broad categories include the comparison of handwriting and hand printing; the comparison of signatures; the comparison of mechanical impressions, such as typewriters, checkwriters, hand stamps, machine stamps, printed matter and machine copies; the examination of altered documents; the restoration of charred papers; the examination of inks and papers; the decipherment of indented writings; and the examination of sequential problems.

An excellent inclusive definition of the Examiner of Questioned Documents, Document Examiner, Document Analyst was authored by Alwyn Cole and published[1] in 1969. This definition was adopted by the American Society of Questioned Document Examiners in 1969 and by the Questioned Documents Section of the American Academy of Forensic Sciences in 1970. Important points made by Mr. Cole in this definition are that practitioners

1. J. Crim. Law, Criminology and Police Science, 60; 4 (1969).

in this field are often referred to as "handwriting experts," whereas document examination includes expertise in handwriting identification, and that document examination does not involve a study of personality.

There is often confusion among the users of this discipline regarding this last point. Graphology, or graphoanalysis, involves the study of handwriting to determine personality or analyze the character of a writer. It bears no relationship to the principles of handwriting identification studies as a part of forensic document examination.

Questioned documents may become the subject of either criminal or civil litigation. Too many people think of this discipline only in terms of checks, credit cards and financial types of crimes. While Financial or white collar crime constitute a good portion of document work, there are numerous other areas in which documents play an important role. In criminal matters, the investigation of homicides, rapes, robberies, burglaries, auto thefts, threats, bombs and arsons may uncover document evidence providing a vital link to a person or persons. Civil actions in which documents come under scrutiny include malpractice cases, paternity suits, patent matters, wills, internal security matters, land and property rights, contracts, and the like.

Credentials of the Document Examiner

There are no undergraduate degree programs in document examination in the United States today. Although document examination is one of the oldest of the forensic science disciplines, it is by many standards a relatively small field. Instruction is provided today, as it has been through the years, by an apprenticeship program in a recognized questioned document laboratory under the direct guidance of a well qualified examiner. It is generally

agreed that an apprentice will receive a minimum of two years instruction covering all areas of document work.

The importance of the training program lies in the opportunity to study actual cases under the close supervision of an experienced examiner. There is absolutely no substitute for this one-on-one basic preparation. In addition, the trainee is expected to become thoroughly familiar with the recognized texts and published articles on document examination.

All persons entering the profession today should possess a baccalaureate degree. This is an absolute requirement for certification and for membership in either of the professional organizations: the American Society of Questioned Document Examiners and the Questioned Documents Section of the American Academy of Forensic Sciences. Both organizations maintain strict requirements of education, training and experience for Associate or Provisional membership and additional requirements of competency for Regular or Fellow status.

Experience in document work is an important consideration if it is based upon the proper foundation of training. The greater an examiner's exposure to varied problems, to studying areas related to documents, to visitations outside the laboratory and to contact with other examiners, the better equipped he becomes in his area of expertise. In addition, independent research, published articles and service to the profession contribute to the experience and competency of the document examiner.

By far the majority of persons engaged in document examination work in government service on the federal, state and local levels. This is also the area where most training is accomplished. However, there are well qualified examiners in private practice who maintain excellently equipped laboratories and do document work on a full-time basis.

The Document Laboratory

The stereo-binocular microscope is the basic instrument used in the examination of all types of document evidence. It is necessary for examining the fine details in writing, for observing defects and alignment in typewriting, for determining methods of printing and copying, for deciphering obliterated and erased writings, for examining sequence problems, and for a host of other document inquiries. The document examiner also makes use of the measuring microscope and comparison microscope in certain instances.

Because photography is an examination tool in addition to being used for illustrative purposes, photographic equipment is utilized by the examiner. Such equipment generally includes cameras, various lenses, filters, films and an enlarger. Different light sources provide capabilities for infrared, luminescence, fluorescence, transmitted and oblique examinations.

The document laboratory will also have available typewriter test plates, reference files on typewriters and other areas bearing a relation to documents, and a library of document books and related specialities. Individual laboratories will supplement this list with equipment or items born out of need, inventiveness or special expertise.

Comparison of Handwriting and Hand Printing

Principles of Identification

The act of handwriting involves an intricate interaction of muscles, nerves and memory. In learning to write, a child attempts to follow a basic form or system of letters. Deviation from the form occurs because of individual differences in ability, skill and perception. As a person's writing progresses, departure from the system becomes more pronounced due to the incorporation of features suited to personal taste and gradual transitions which tend to facilitate an ease and speed of writing. It is the extent of departure from the writing system learned that produces individuality in handwriting and hand printing.

Generally, a person's writing style has developed by the early twenties but does continue to change gradually, unless extraordinary physical or emotional health problems occur which may affect writing. By repetition, the act of writing becomes automatic so that the writer can concentrate on subject matter rather than forming words.

Class and individual characteristics are the basis for identification of handwriting and hand printing. It is not only critical that in the identification process important and sufficient class and individual characteristics be present, there also must be an absence of any consistent, fundamental differences between the known and the questioned writings. A fundamentally different characteristic can be defined as a personal writing trait of the author, i.e., it appears consistently in the author's writings. Importantly, it is not found in the writing to which it is being compared.

Additional differences reinforce this opinion. Essentially, in an identification, all of the characteristics of the questioned writing will fall within the range of the known writing and be capable of explanation through the known writing (Fig. 1).

Handwriting and hand printing executed by different writers, particularly those who have learned the same system of writing and possess a similar writing skill, may show pictorial similarity in some letter forms. Such features, by themselves, should not be mistaken for identity. Identification is not based upon one or two similar features between two writings but upon a unique combination of all characteristics of the writing. Cognizance must be taken not only of letter design but of the size and proportion of parts of a letter to the whole and of letters in relation to each other, the manner of forming beginning and ending strokes, shading, pen movement, spacing, and alignment and arrangement of the material.

Another factor that must be understood and properly evaluated in the total picture of identification is that of natural variation. Natural variation is an intrinsic characteristic of writing in that no two writing specimens are exactly alike. Slight variations in basic form occur throughout one individual's writing. Natural variation in one person's writing is distinguishable from basic differences between two different writers. Some writers exhibit more natural variation in their writing than others; however, the extent of this quality can be assessed with a sufficient quantity of an individual's writing.

It is sometimes thought that hand printing is not identifiable in the same sense that one's handwriting is recognizable. Perhaps for this reason, it is often used as a supposed disguise in anonymous communications. Hand printing today is a common method of writing and becomes individualized in

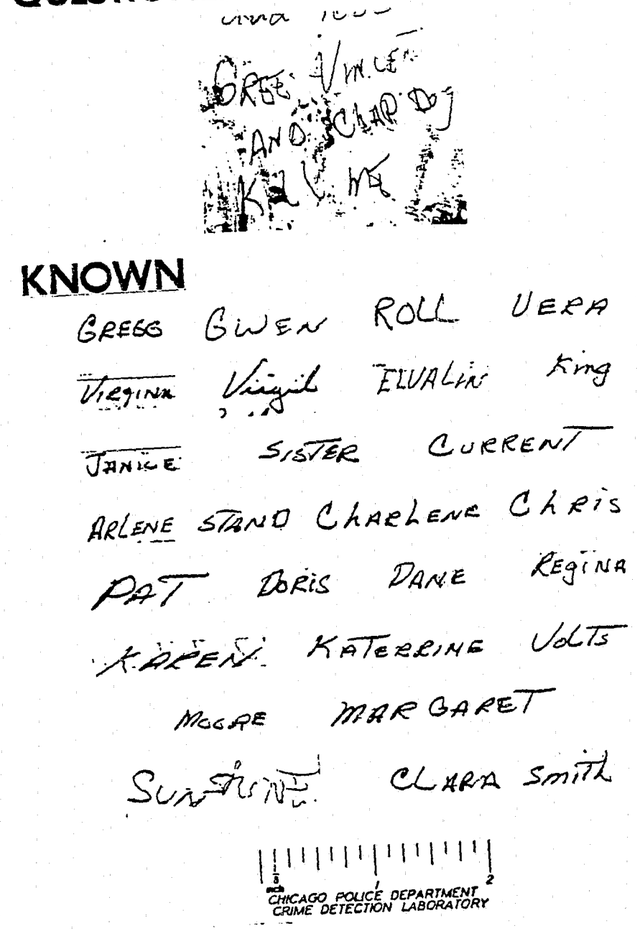


FIG. 1. A COMPARISON CHART USED TO DEMONSTRATE THE BASIS FOR AN OPINION IN COURT. THE QUESTIONED MESSAGE WAS WRITTEN ON THE FIRST INSIDE PAGE OF A SMALL (ABOUT 2" x 3") NAME AND ADDRESS BOOK, THE PAPER BEING BLOOD-SPATTERED. IT WAS FOUND NEXT TO A DYING YOUTH AT THE SCENE, AND LATER DETERMINED TO BE HIS BOOK. THE VICTIM WAS IDENTIFIED AS WRITING THE MESSAGE. TESTIMONY WAS FIRST PRESENTED AT A HEARING TO RULE ON THE ADMISSABILITY OF THIS EVIDENCE AS A DYING DECLARATION OR ITS INADMISSABILITY AS HEARSAY EVIDENCE. THE EVIDENCE WAS FOUND TO BE ADMISSIBLE AND TESTIMONY AGAIN PRESENTED AT TRIAL.

much the same manner as handwriting - by training, the perception of letter forms, the skill in executing letter forms, and the incorporation of characteristics suited to individual taste. Hand printing is simply a combination of unconnected letters grouped to form words. As such, it contains all of the individual elements used in identifying handwriting, with the exception of connecting strokes between letter forms. In some cases, hand printing is found to be a mixture of manuscript and script letter forms, frequently showing hairline connections between certain letters. This is particularly true of persons who hand print regularly and consequently develop a speed comparable to that of handwriting.

Standards of Comparison

The document examiner is often asked why so much writing and specific types of writing are needed for comparison in any given case. The answer to this query is very simple--to arrive at the truth concerning the authorship or genuineness of a questioned writing, to determine who did, and who did not, produce the writing in question. Two conditions must be met to make a valid comparison with a questioned exhibit: there must be enough material to compare and the material must be comparable. Since writing varies over time, it is sometimes necessary for standards to approximate the time period of the questioned writing.

No definitive statement can be made regarding sufficiency of standards which will encompass all handwriting problems, as each case must be considered individually. Normally, there must be a sufficient amount of comparison writing to encompass the natural variation of a person's hand. The more variation in a person's writing, the greater the need for extensive standards in order to observe the full range of characteristics. In this context also,

where the writing in question is very limited, a greater amount of standard material will usually be required.

Comparable known material is writing of the same class which contains the same letter forms and combinations of letter forms found in the questioned writing and, if possible, duplicates the text of the questioned writing. In addition, comparable standards are those in which an attempt is made to obtain writing prepared under conditions similar to those under which the questioned writing was prepared (Fig. 2). As examples, handwriting is compared with handwriting, hand printing with hand printing (taking into consideration upper or lower case), disputed signatures with genuine signatures, and numerals with numerals. The name Albert Smith cannot be compared with the name John Jones because there are no letter forms in common. Even if there were one or two letter forms in common between these names, the whole would not be comparable. All of the letter forms, in sufficient quantity to encompass variation, must be present in the standards. Consideration must also be given to writing prepared under varied conditions; that is, formal writings, hurried writings, confined writings, those prepared in an unusual writing position or on an unusual writing surface, writing executed in ill health, or other such circumstances. These conditions will influence the type of standards needed for comparison.

Because handwriting is not static but changes gradually over a period of time and because extraordinary circumstances of physical or emotional health may effect sudden changes in handwriting, it is sometimes necessary to obtain standards approximate or current to the writing in question (Fig. 3). Such conditions may have progressed over a period of time or they may be temporary in nature. Again, it is necessary to consider each case based upon its own merits and circumstances of writing.

QUESTIONED DOCUMENT

...ng, drainage, water

...ased on the dollar

; Full Ser
lasic Fee

Agreement
2 May 73

15.0%
12.0%
11.0%
10.0%
9.5%
9.0%
8.5%
8.0%

15.5
13.5
11.5
10.5
9.5

DICTATED STANDARDS

Paul E. Peters
1-26-78

17.5 PER
5.5 PER
13.5 PER
11.5 PER
11.0 PER
10.5 PER
10.0 PER
9.5 PER

Witnessed: K. Oneal

CHICAGO POLICE DEPARTMENT
CRIMINALISTICS DIVISION

1/8 inch

FIG. 2. THE INITIALS "PER" ON THE AGREEMENT ARE IN QUESTION. THE DICTATION WAS PREPARED TO OBTAIN STANDARDS WHICH SIMULATE AS CLOSELY AS POSSIBLE THE CONDITIONS UNDER WHICH THE QUESTIONED WRITING WAS PREPARED.

Questioned
11-24-75

Lula St James

Distributor

Known
4-13-74

Lula St James

7-5-77

E Lula St. James

ATURE Lula St James

ITY

FIG. 3. BECAUSE THE '77 DICTATED SIGNATURES WERE OF POOR QUALITY (DUE TO AGE AND ILLNESS), IT WAS NECESSARY TO PROCURE SPECIMEN SIGNATURES PREPARED PRIOR TO THE DATE OF THE QUESTIONED SIGNATURE TO DETERMINE WRITING HABITS AND ABILITY AT THAT TIME. BASED UPON THE ADDITIONAL WRITINGS, THE QUESTIONED SIGNATURE WAS DETERMINED TO BE NON-GENUINE.

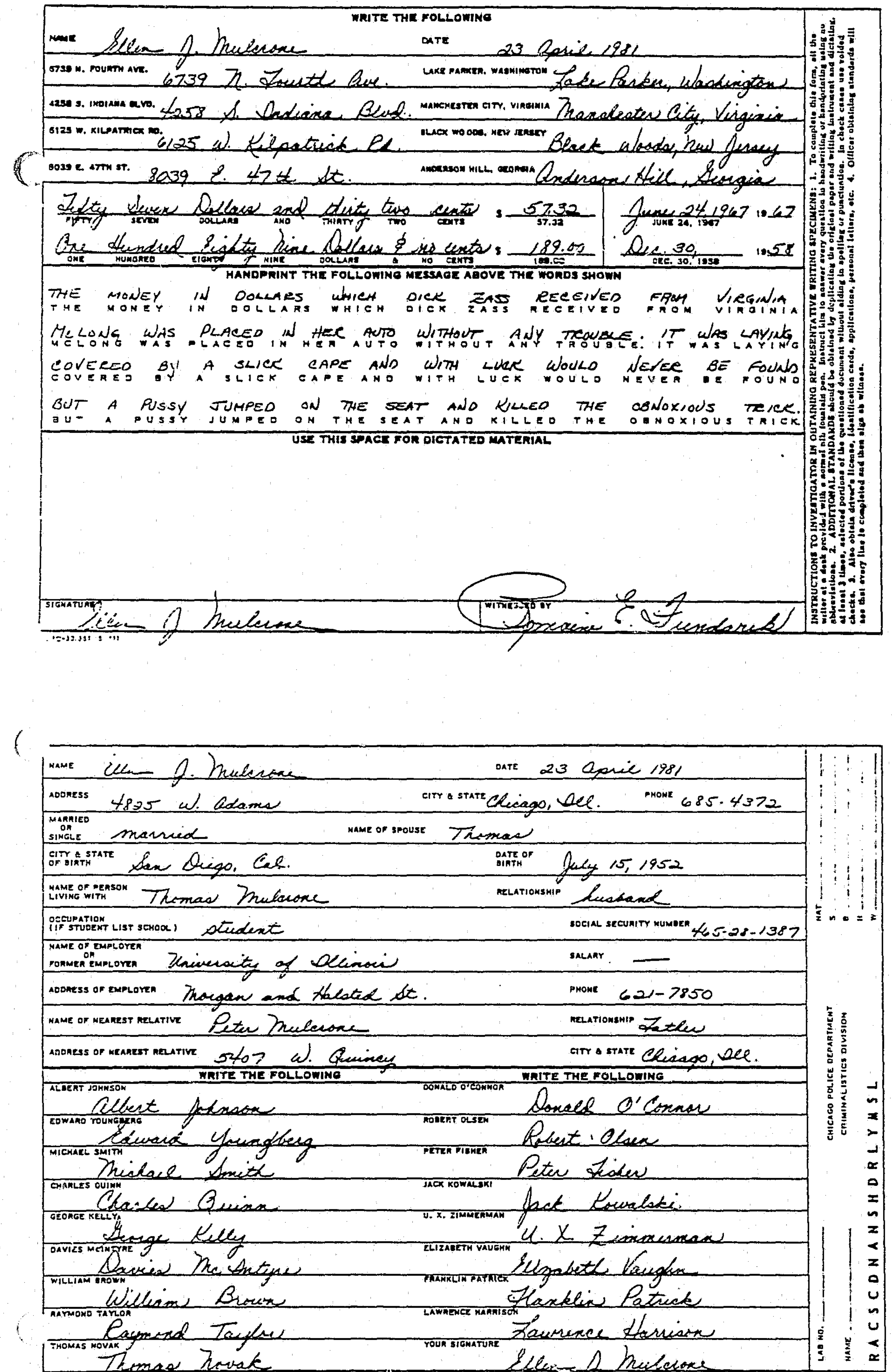

WRITE THE FOLLOWING
NAME Ellen J. Mulerone DATE 23 April 1981
6739 N. FOURTH AVE. 6739 N. Fourth Ave. LAKE PARKER, WASHINGTON Lake Parker, Washington
4258 S. INDIANA BLVD. 4258 S. Indiana Blvd. MANCHESTER CITY, VIRGINIA Manchester City, Virginia
6125 W. KILPATRICK RD. 6125 W. Kilpatrick Rd. BLACK WOODS, NEW JERSEY Black Woods, New Jersey
3039 E. 47TH ST. 3039 E. 47th St. ANDERSON HILL, GEORGIA Anderson Hill, Georgia
FIFTY SEVEN DOLLARS AND THIRTY TWO CENTS $ 57.32 JUNE 24, 1967
ONE HUNDRED EIGHTY NINE DOLLARS & NO CENTS $ 189.00 DEC. 30, 1958
HANDPRINT THE FOLLOWING MESSAGE ABOVE THE WORDS SHOWN
THE MONEY IN DOLLARS WHICH DICK ZASS RECEIVED FROM VIRGINIA
MCLONG WAS PLACED IN HER AUTO WITHOUT ANY TROUBLE. IT WAS LAYING
COVERED BY A SLICK CAPE AND WITH LUCK WOULD NEVER BE FOUND
BUT A PUSSY JUMPED ON THE SEAT AND KILLED THE OBNOXIOUS TRICK
USE THIS SPACE FOR DICTATED MATERIAL
SIGNATURE Ellen J. Mulerone
WITNESSED BY
NAME Ellen J. Mulerone DATE 23 April 1981
ADDRESS 4825 W. Adams CITY & STATE Chicago, Ill. PHONE 685-4372
MARRIED OR SINGLE married NAME OF SPOUSE Thomas
CITY & STATE OF BIRTH San Diego, Cal. DATE OF BIRTH July 15, 1952
NAME OF PERSON LIVING WITH Thomas Mulerone RELATIONSHIP husband
OCCUPATION (IF STUDENT LIST SCHOOL) student SOCIAL SECURITY NUMBER 465-28-1387
NAME OF EMPLOYER OR FORMER EMPLOYER University of Illinois SALARY —
ADDRESS OF EMPLOYER Morgan and Halsted St. PHONE 621-7850
NAME OF NEAREST RELATIVE Peter Mulerone RELATIONSHIP Father
ADDRESS OF NEAREST RELATIVE 5407 W. Quincy CITY & STATE Chicago, Ill.
WRITE THE FOLLOWING
ALBERT JOHNSON Albert Johnson
EDWARD YOUNGBERG Edward Youngberg
MICHAEL SMITH Michael Smith
CHARLES QUINN Charles Quinn
GEORGE KELLY George Kelly
DAVIES MCINTYRE Davies McIntyre
WILLIAM BROWN William Brown
RAYMOND TAYLOR Raymond Taylor
THOMAS NOVAK Thomas Novak
WRITE THE FOLLOWING
DONALD O'CONNOR Donald O'Connor
ROBERT OLSEN Robert Olsen
PETER FISHER Peter Fisher
JACK KOWALSKI Jack Kowalski
U. X. ZIMMERMAN U. X. Zimmerman
ELIZABETH VAUGHN Elizabeth Vaughn
FRANKLIN PATRICK Franklin Patrick
LAWRENCE HARRISON Lawrence Harrison
YOUR SIGNATURE Ellen J. Mulerone
CHICAGO POLICE DEPARTMENT CRIMINALISTICS DIVISION
R A C S C D N A N S H D R L Y M S L

FIG. 4. THE FACE AND BACK OF THE HANDWRITING STANDARD FORM.

Dictated Writings

Dictated writings are those prepared specifically for the purpose of comparison with questioned writings in a given case or investigation. Since dictated standards constitute the most common type of comparison material in criminal cases, the role of the investigator in obtaining suitable standards cannot be overemphasized. The document examiner will base an opinion as to the authorship or genuineness of questioned writings on the comparison material provided, and the substance of that opinion will generally reflect the quality of the standard material submitted. There will certainly be cases where the quality of the questioned writing will preclude a definite opinion or any opinion at all, even with the best of standards; however, inconclusive opinions will result more often from poor quality or improper writing standards.

The use of standard form for handwriting is practiced by most document laboratories as a means by which to obtain a portion of the dictated material at (Figure 4) is a sample of such a form.[2] With it, a document examiner can obtain an acceptable amount of initial dictated material. Note that the upper half of the form takes advantage of everyone's familiarity with an application form whereas the lower half includes proper names common to the local area. It is designed to include almost all upper and lower case letters and the common combinations of letters.

On the reverse side, more common combinations are included. The lower portion of the back of the form is for additional dictation from the material in question. The handwriting form provides the initial step in the attempt to obtain suitable and sufficient standards of comparison. No handwriting standard form could be devised, however, which would provide sufficient and

2. For a detailed explanation of the makeup of the form, see David J. Purtell, "Handwriting Standard Forms", Journal of Criminal Law, Criminology and Police Science, 54: 4 (1963), pp. 522-528.

suitable material for comparison in each and every case, so it should be expected that a handwriting form, by itself, will fall short of the examiner's needs in a number of instances.

Whenever possible, the handwriting form should be supplemented with additional dictated specimens. Such specimens should duplicate the form, contents, writing instrument and writing conditions of the questioned document as closely as possible. This will not only provide a greater quantity of writing for comparison but will also provide standards more comparable to the material in question. The specimen forms can be hand drawn on a plain sheet of paper and machine copied or a blank form of the original document can be machine copied. Each of the questioned writings should be dictated several times.

When obtaining dictated handwriting specimens certain rules should be observed in order to secure the best possible material. The subject should be seated in a quiet room or in an area away from possible distractions. The person witnessing the standards should remain in the presence of the subject and watch the execution of all specimens. Each specimen should be removed from the subject after execution. Dictation of material should be gauged so that the subject writes spontaneously and continuously rather than at an erratic pace. The investigator may wish to record the time elapsed in execution of the standards for later reference. The subject should be allowed or required to rest at intervals so that he does not become tense from continuous writing. If it is suspected that the questioned writing was prepared under unusual circumstances (for example, writing on a clipboard while standing), some standards prepared in this manner should be secured. Under no circumstances should the investigator allow the individual to copy from the actual document in question.

Court-Ordered Writings

An arrested person who refuses to give handwriting standards voluntarily may be compelled to do so by the court of jurisdiction. Likewise, a person presumed to have knowledge of or a part in certain events may be subpoenaed before a grand jury investigating the matter and ordered to provide handwriting standards. In either case, a refusal to comply with the order can result in that person being cited for contempt of court. The procurement of handwriting standards for comparison has been regarded by the U.S. Supreme Court to be non-testimonial or noncommunicative evidence and, therefore, not protected by the self-incrimination clause of the Fifth Amendment. A number of cases have considered the subject of comparison standards, but the Gilbert and Schmerber decisions[3] are particularly relevant to handwriting.

Court-ordered standards are dictated standards and the same rules for obtaining them apply. The difference is that they are not voluntary standards and the problem of disguise may be a major problem. With court-ordered standards, there is a time interval not present when standards are obtained upon arrest, so that a person has an opportunity to write a well conceived and practiced disguise. Such specimens can be self-serving standards. There are instances where a court restricts the amount and type of writing a subject has to give. Such restrictions can also impose limitations on the examination and resultant findings. Attempt to disguise court-ordered handwriting standards may be viewed as evidence

3. Gilbert v. California, 388 U.S. 263, 87 S.Ct. 1951 (1967); Schmerber v. California, 384 U.S. 757, 86 S.Ct. 1826 (1966)

of contempt of the order. When this occurs, the examiner's report should indicate material which is disguised to the extent that the examiner can make no meaningful comparison with the questioned writings.

Collected Writings

Collected writings are those prepared at a time and for a purpose other than the present investigation. As a rule, such standards contain undisputedly normal writing of an individual for there would have been no reason to disguise them at the time they were prepared. For this reason collected standards, if comparable, are an excellent source of comparison material and an attempt should be made to obtain them whenever possible (Fig. 5). An important consideration with collected writings is that they be capable of being verified as the writing of a certain individual. If this cannot be done, an opinion based upon such material would prove useless. There are numerous sources of collected writings, including work related forms such as applications and W-4's, cancelled business and personal checks, writings prepared as a part of business transactions, social correspondence, and the like.

Disguised Writings

Handwriting or hand printing comparisons constitute the greater portion of a document examiner's cases. Suitable comparison standards, therefore, assume great importance in attempting to resolve these problems. Disguise is a deliberate attempt on the part of the writer to alter his natural habits of writing in order to make identification of the writing impossible. The problem in dealing with disguise is equal to how proficient the writer is in achieving this goal. Since disguise is more often observed in standards of comparison than in questioned writings, it is the

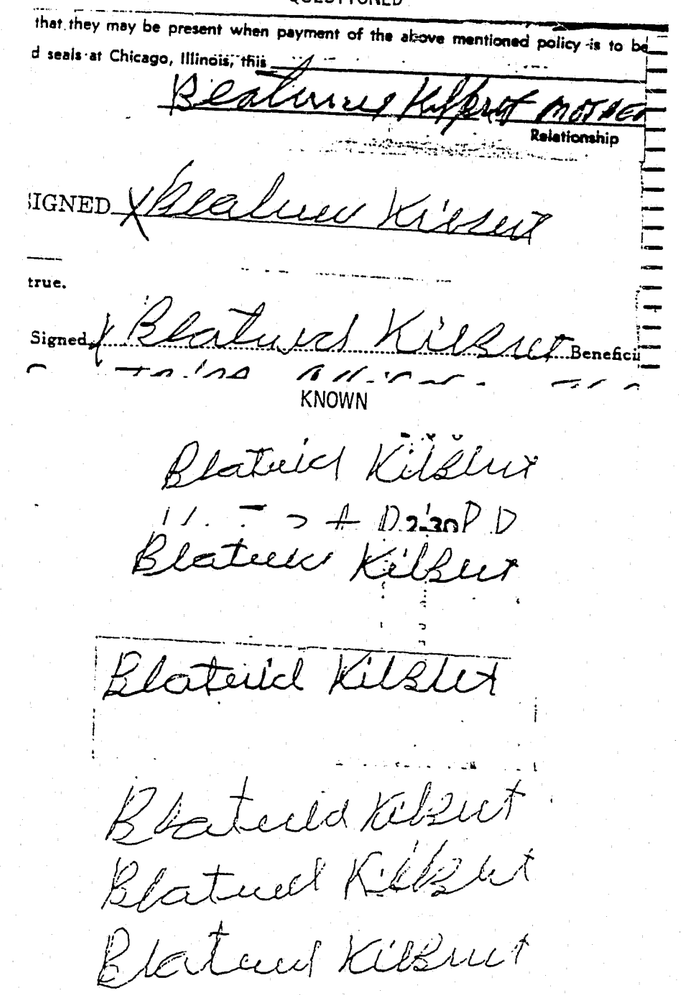


FIG. 5. THE CASE INVOLVED TURNING OVER THE PROCEEDS OF AN INSURANCE POLICY TO A FUNERAL HOME AND THE VICTIM COULD NOT REMEMBER EXACTLY WHAT DOCUMENTS SHE HAD SIGNED. IN ADDITION TO THE DICTATED STANDARDS SUBMITTED, IT WAS REQUESTED THAT COLLECTED SIGNATURES BE OBTAINED TO OBSERVE THE QUALITY AND VARIABILITY OF THIS WRITING OVER A TIME. THE TOP QUESTIONED SIGNATURE IS A SIMULATED FORGERY AND ALTHOUGH THE AUTHOR ATTEMPTED TO REPRODUCE THE QUAVERY MOVEMENTS OF THE GENUINE SIGNATURES,SUPERIOR WRITING QUALITIES OF WHICH THE KNOWN WRITER IS NOT CAPABLE ARE SEEN IN THE SIGNATURE. THE "T" IN BEATRICE AND "R" AND "T" IN KILBRET ARE EXAMPLES. THE BOTTOM TWO QUESTIONED SIGNATURES ARE GENUINE, REFLECTING THE QUALITY AND NATURAL VARIATION FOUND THROUGHOUT THE KNOWN SIGNATURES.

goal of the investigator to obtain suitable, normal writing for comparison purposes.

Most people find it difficult, if not impossible, to sustain an effective disguise when executing lengthy, continuous material. This is, in part, a reason for requesting a large amount of standard writing. With time, the investigator will be able to recognize the more common tactics of disguise and find the best means of obtaining normal writing. Some of the more common methods of disguise are: writing with extreme rapidity so that the material resembles a series of strokes rather than a legible script, writing with extreme slowness and forming each letter with inordinate care, writing with a heavy pressure wherein the hand will soon become taunt, writing with an opposite slant, writing extremely small and crowded so that the material is barely readable, and writing extremely large and out of proportion. A writer may combine handwriting and hand printing or a combination of the above methods revealing an obvious inconsistency in the overall material. Writing with the unaccustomed hand is a method less often used in disguise but can usually be recognized because of the poor quality and inconsistency of the writing. Disguised writing often shows numerous interruptions of the pen strokes and overwritings.

Comparison of Signatures

Elements of Genuineness and Non-genuineness

When a comparison of signatures is requested to ascertain genuineness or forgery, the standards must include signatures of that individual in sufficient number to reveal the writer's signature writing variability. Signatures may very radically from an individual's general handwriting. When possible, the standards should be obtained during the time period when

the questioned signature was written. The standards should also be of the same type or under the same conditions as the questioned signature; formal vs. informal or unusual situations.

The identification of a signature as genuine is based upon the same principles of identification as that of general handwriting; however, certain aspects of the writing will assume greater importance in signature comparison than would be the case with general handwriting. The writing movement used to produce a signature is an important consideration in determining whether a signature is genuine or non-genuine. Genuine signatures will exhibit a certain degree of speed, skill, freedom, continuity and pen pressure, all of which contribute to the individual writing movement. These elements are among the most difficult to imitate and the area in which forgeries are usually deficient.

The most commonly encountered methods of signature forgery are those of tracing, simulation, and what may be termed spurious, although sometimes a transfer method, by physical, mechanical or chemical means, is seen. A traced forgery is the outlining of a genuine signature from one document onto another document upon which the forger wishes it to appear. Depending on the method used, the outline may be the final result or it may be overwritten to produce the final result. Where the outline is overwritten, evidence of pencil lead, carbon or indentations are usually observed beneath the resultant signature.

A simulated forgery is an attempt to copy in a free-hand manner the characteristics of a genuine signature either from memory of the signature or from a model. In some cases, the forger may spend considerable time practising the signature to be imitated before producing the final result.

A spurious forgery is one prepared primarily in the author's own handwriting with little or no attempt to copy the characteristics of the genuine writing.

Traced signatures are basically drawings and consequently lack much of the free, natural movement inherent in a person's normal writing. Simulated signatures, on the other hand, will vary in quality according to a number of factors including the writer's skill as a penman, the difficulty of the signature being imitated, the writer's ability to recognize and incorporate detail, the writer's ability to concentrate on the significant features of the signature, practice of the signature to be imitated, and throughout all of the writing, his ability to simultaneously discard all of his own natural habits of writing. In addition, the forger must choose a signature in the relevant time period and pay close attention to normal variation in the writing, particularly when more than one forgery must be prepared. The difficulty of executing the so-called perfect forgery becomes apparent and although simulated signatures are generally the better of the above two classes of forgery, they will most often not go undetected under close scrutiny (Fig. 6).

Traced and simulated forgeries sometimes appear recognizable on their face; traced forgeries showing evidence of an outline, and both types showing evidence of a drawn appearance, i.e., slow and uncertain pen movement. Upon comparison with genuine signatures, specific defects become more apparent. Some of these defects are: hesitation points in the writing, liftings of the pen in unusual places, patchings, incorrect manner of forming some letters, incorrect proportions, incorrect shading or lack of shading, tremulous movements, abrupt beginning and ending strokes, and a lack of inconspicious details. It should be noted that not all simulated signatures contain gross evidence of forgery. Some

Matthew W Thomas

Matthew W Thomas

Matthew W Thomas

Matthew W Thomas

Matthew W Thomas

NAME Matthew W Thomas

ADDRESS

FIG. 6. THE TOP THREE SIGNATURES ARE QUESTIONED; THE BOTTOM SIGNATURES ARE KNOWN. THE QUESTIONED SIGNATURES ARE SIMULATIONS OF A GENUINE SIGNATURE OF MATTHEW W. THOMAS. EVIDENCE OF FORGERY INCLUDES ADDED STROKES, BLUNT BEGINNINGS AND ENDINGS, TREMULOUS MOVEMENTS, PEN LIFTS, HESITATION POINTS, LACK OF SHADING, IMPROPER MOVEMENT, ETC.

forgeries are well executed and are faulted only by subtle but persistent discrepancies with the genuine signatures (Fig. 7).

Because traced and simulated signatures are an attempt to copy another person's handwriting characteristics, the authors of these types of forgeries are seldom identified. Only if the author of such a forgery were to do a particulary unskillful imitation or were to imitate only a portion of the genuine signature, such as the capital letters, thereby leaving the greater portion of the writing to contain his own natural habits, would the possibility of identification exist. Spurious forgeries, because they are prepared without benefit of a model signature, always possess the possibility of identification exist. Spurious forgeries, because they are prepared without benefit of a model signature, always possess the possibility of identification of the author.

Unusual Signature Problems

Whenever the signature is directly affected by a physiological condition of the writer special problems exist. The handwriting of elderly persons is a case in point. . . or the handicapped, or those who are ill. Alcohol and drugs can also affect writing. When one person guides another's hand is also an unusual case. Characteristics of these signature problems include: writing which is badly deteriorated, signatures executed with great difficulty or those which contain irregular or confused movement, or signatures that appear erratic in portion. Again, in each of these cases the individual circumstances of the writing must be considered. Special care must be to obtain standards which reveal the previous and present writing habits of the person.

Another special signature case is the comparison of initials, involving

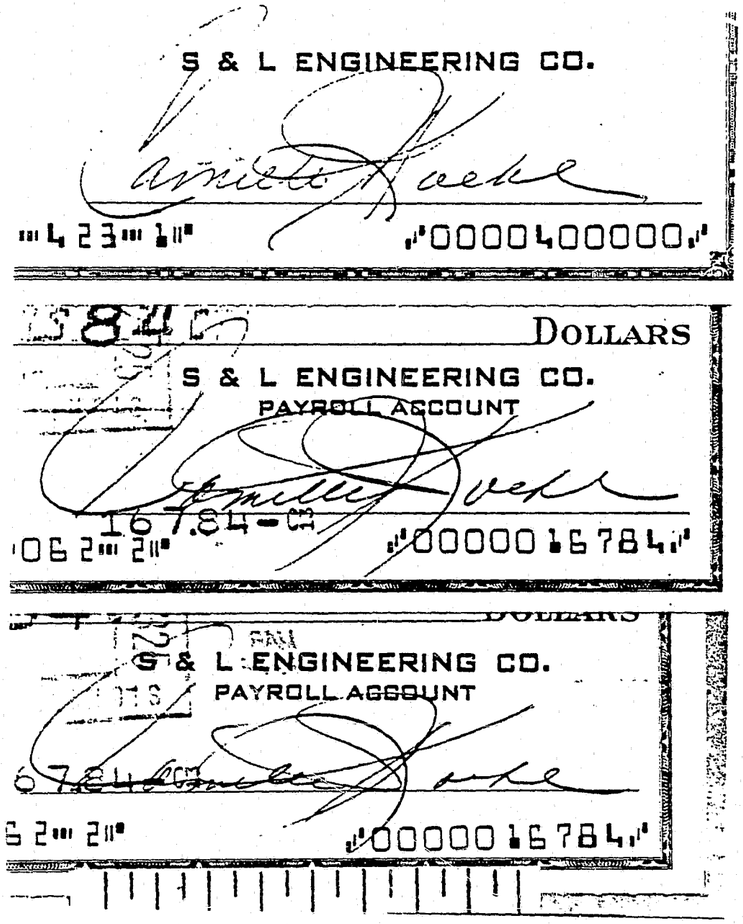


FIG. 7. THE TOP SIGNATURE CAMILLE H. KOEHE IS IN QUESTION; THE BOTTOM SIGNATURES ARE A PORTION OF THE KNOWN MATERIAL. THE QUESTIONED SIGNATURE IS A SIMULATED FORGERY. THE MOST TELLING DIFFERENCE IS THE MANNER OF FORMING THE "HK" COMBINATION - THE QUESTIONED IS FORMED IN AN OPPOSITE MANNER TO THE GENUINE. OTHER SUBTLE, BUT PERSISTENT DIFFERENCES CAN ALSO BE SEEN.

only two or three letters. However, if initials are used regularly by a person in signing certain types of documents, they become as individual to the person as his signature (Fig. 8). Needless to say, great care must be exercised in examining such limited material and good standards of comparison are imperative.

Comparison of Mechanical Impressions

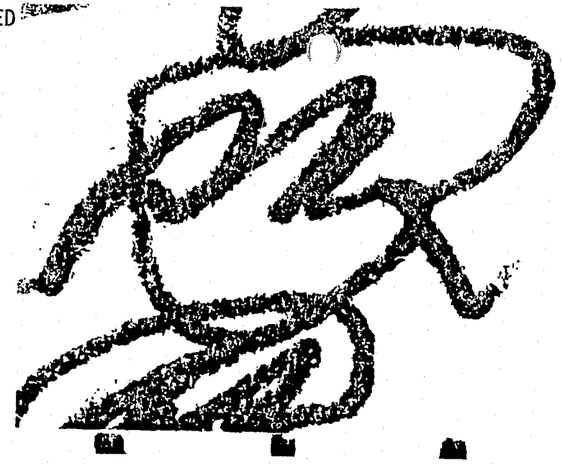
Typewriting

Problems Encountered in Typewriting

The examination of typewriting is an important area of questioned document work as it involves a good number of those communications which are not handwritten and a good bulk of legal and business documents in existence today. Typewriting problems are most often thought of in terms of identifying a typewritten communication with a specific machine, when in fact, other possibilities exist. Additions or substitutions of typewritten matter to an existing typewritten document after it has been signed or legalized in some manner may serve to alter the contents or context of the document. Such alterations can range from one character to an entire page, prepared on the same machine or on one having a type face closely resembling that used to prepare the original document. Another possibility is to establish the relative time period in which a typewritten document was prepared. This may be accomplished through dating of the introduction of the type face or dating from the previous work of a typewriter over a period of time.

In cases where a carbon film ribbon has been used to prepare the typewriting in question, it may be possible to establish that the ribbon was used to prepare the typewritten material (Fig. 9). Carbon film ribbons

QUESTIONED



KNOWN

FIG. 8. AN ENLARGEMENT OF THE INITIALS FROM FIG. 2 TO SHOW DISCREPANCIES BETWEEN THE KNOWN AND QUESTIONED SAMPLES.

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UNITED STATES DEPARTMENT OF AGRICULTUR
SPECIAL AUTHORIZATION TO PURI

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BARR, PATRICIA
194 W. 154th Street
HARVEY, ILLINOIS 60426

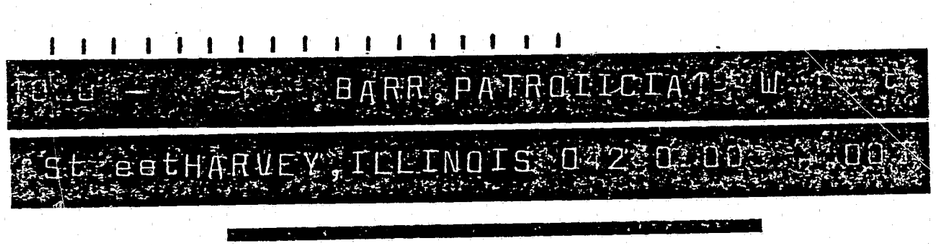


FIG. 9. IDENTIFICATION OF THE TYPEWRITER RIBBON USED IN PREPARING THE FACES OF A SERIES OF AUTHORIZATION CARDS. THE LETTER "O" IN PATRICIA WAS TYPED IN ERROR AND THEN OVERTYPED WITH THE LETTER "I".

do not overlap characters, as fabric ribbons do, and therefore can be read (Fig. 10). Consideration should be given to cover-up and lift-off tapes used in conjunction with film ribbons. These tapes are used to correct errors in the typing and may contain significant evidence when compared with the questioned typewriting.

Typewriter Standards

In the identification of the typewriter used in the preparation of questioned document, the initial step is the identification of the type style used, in anticipation that it will narrow the search for the brand of typewriter used.[4] Today not all type styles can be related to a single make of machine as many type face manufacturers sell the same type faces to a number of typewriter manufacturers. Once a suspect machine has been located, standards may be obtained for comparison with the questioned exhibit. Whenever possible, the suspect typewriter should be submitted to the document examiner giving him an opportunity to examine the machine as well as obtain standards under varied conditions. If this is not possible, suitable typewriter standards may be provided following a format similar to that shown in Figure 11.

Typewriting standards should include: make, model, serial number, whether or not it uses a two-ribbon system, etc. All keys should be typed at least two times and the questioned material, depending upon its

4. For this and other typewriting problems, document examiners maintain an extensive typewriter reference file covering domestic and foreign styles of type, dates of introduction of type styles, dates of changes in type styles and design modifications of typewriters.

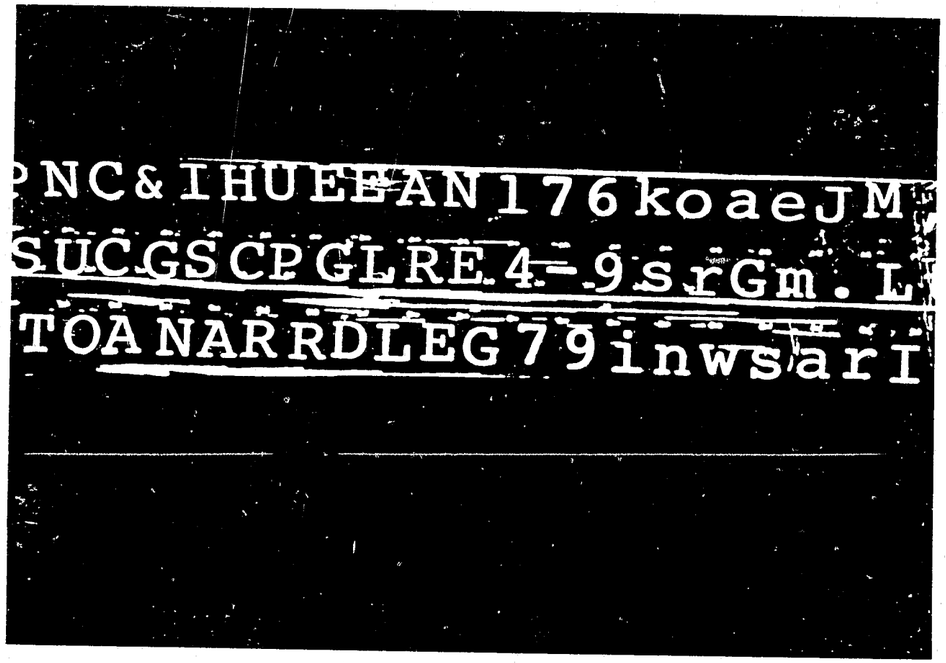


FIG. 10. THE TYPEWRITER WAS RECOVERED AND THE POLICE DEPARTMENT WISHED TO TRACE THE RIGHTFUL OWNER. THE SERIAL NUMBER WAS OBLITERATED BEYOND CHEMICAL RESTORATION. INFORMATION READ FROM THE CARBON FILM RIBBON WAS USED TO TRACE THE OWNER. THE RIBBON IS READ ALTERNATELY FROM THE BOTTOM TO THE TOP ROW, EACH LETTER STAGGERED SLIGHTLY TO THE LEFT.

FORMAT FOR TYPEWRITING STANDARDS

INSTRUCTIONS	
TYPEWRITER IDENTIFICATION	IBM Electric Typewriter, Serial Number 11-95342, located at 1111 South Michigan, 5th floor, Room 599, owned by the Neverready Company and assigned to Mr. J. Jones.
ENTIRE KEYBOARD --TWICE	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 1234567890-=½;'../ !@#$%¢&*()_+¼:"..? ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 1234567890-=½;'../ !@#$%¢&*()_+¼:"..?
MESSAGE	This is a warning to you and your family. We know where you live. If you don't put $10,000 in a brown envelope and place it under the rock near the second pillar North of the "L" station on Ashland Ave. we will kill your son. We mean business. This is a warning to you and your family. We know where you live. If you don't put $10,000 in a brown envelope and place it under the rock near the second pillar North of the "L" station on Ashland Ave. we will kill your son. We mean business.
CARBON PAPER IMPRESSION	
ENTIRE KEYBOARD	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 1234567890-=½;'../ !@#$%¢&*()_+¼:"..? ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 1234567890-=½;'../ !@#$%¢&*()_+¼:"..?
MESSAGE	This is a warning to you and your family. We know where you live. If you don't put $10,000 in a brown envelope and place it under the rock near the second pillar North of the "L" station on Ashland Ave. we will kill your son. We mean business.
TYPIST IDENTIFICATION	This material was typed by Det. Earl E. Morn, #1961, 45th Dist., on 31 January 1971 at the above listed location.

TO OBTAIN CARBON PAPER IMPRESSION--SET MACHINE FOR STENCIL AND PLACE CARBON PAPER IN FRONT OF TYPING PAPER

WHEN TYPING, VARY DEGREE OF TOUCH--HEAVY, MEDIUM AND LIGHT

FIG. 11. FORMAT FOR OBTAINING TYPEWRITING STANDARDS.

extensiveness and repetition, should be typed at least twice, adhering as closely as possible to the arrangement and spelling of the questioned text. If a variable pressure feature is present a full range of pressures should be obtained in an attempt to match the conditions of the original typing. Carbon impressions reveal the condition of the type face. By placing the machine on stencil and typing through an unused section of carbon paper placed in front of the paper a good carbon impression is obtained.

Identification of Type Bar Machines

Once the class characteristics of size and design of type and line spacing for a machine are found to be in general agreement with that used for a questioned document the actual identification rests upon the machine's individual characteristics - those peculiarities which individualize that machine (Fig. 12). Individual characteristics generally fall into two classes, defects in the type face and defects in alignment. These defects are most often caused through wear or misuse of the machine, although manufacturing defects are a possibility. Occasionally, machine defects, such as improper escapement action, irregular margin stops, improper ribbon action or improper platen alignment, can add to the identification formula.

A standard or electric type bar machine contains 44 keys or type bars (88 characters) operating independently of one another, each of which is liable to potential damage. Damage can result from a variety of causes and affect either the metal type face or the alignment of the type bar. Examples of type face defects include broken or missing serifs and dented or otherwise defective characters. Alignment defects include characters which print above or below the base line of typing, to the left or right or center, canted from the perpendicular, or more heavily on one side than

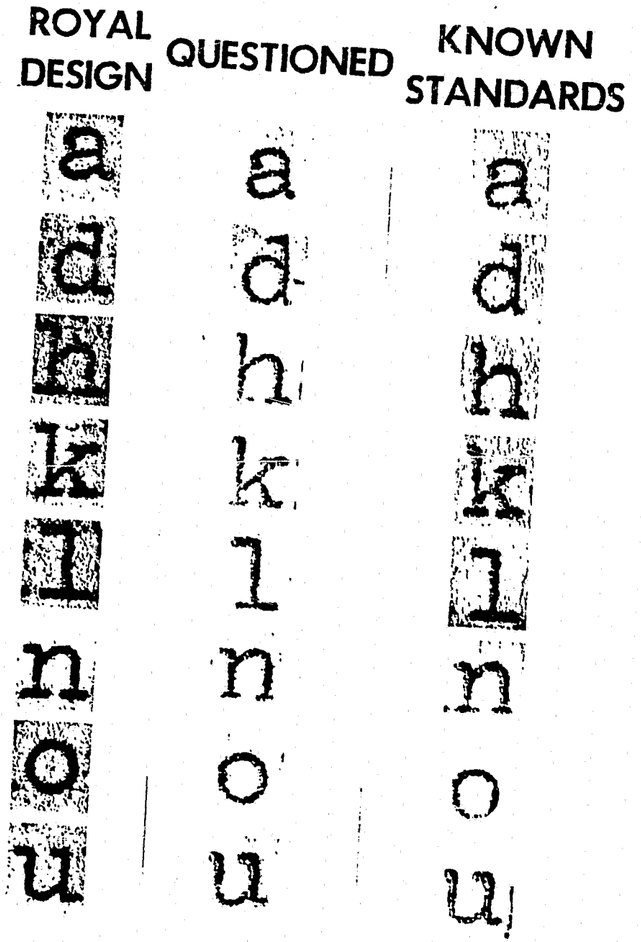


FIG. 12. A CHART PREPARED FOR TESTIMONY ON A TYPEWRITER IDENTIFICATION. ILLUSTRATED ARE THE TYPE DESIGN AND TYPEFACE DEFECTS IN BOTH THE QUESTIONED AND KNOWN MATERIAL.

another.

The number of defects, although important, is not the primary criterion since not all type face and alignment defects bear equal weight or consideration in a comparison. The manner in which characters are defective, possible causes of the defects and incidence of letter usage all contribute to the final valuation. The combination of defects must be such that the possibility of another machine, of similar class characteristics, having exactly the same individual defects is virtually nonexistant.

Identification of Single Element Machines

The first single element machine, the Selectric, was introduced in 1961 by IBM. A significant departure from the old type bar design, the Selectric consists of a single, interchangeable typewriting element and a stationary platen. The typewriting element is mounted on a carrier unit which moves the element across the paper and also controls its movements of rotation, tilt and forward motion. Because the operation of this machine is entirely different from that of a type bar machine, the usual criteria for establishing identification are no longer entirely valid and the identification problem had to reanalyzed.

The Selectric typewriter contains two basic components, the machine proper and the removable typing element. The combination of a particular typing element used on a particular machine, is the entity considered when comparison is made with a questioned document. That particular system would no longer exist if, for instance the typing element were to be discarded after the questioned document had been typed. Elements and machines must be carefully marked to identify each unique unit. Individual type face defects do not occur as often with a Selectric as with the type

bar machine. Alignment defects, arising from irregularities in both the operation of the typing element and the operation of its controlling mechanism, are the primary basis for identification. Occasionally, type element defects occurring as a result of a manufacturing process will be a contributing factor in the identification. Extreme care must be used in evaluating defects from a Selectric machine as they are significantly more subtle than those found with a type bar machine.[5] Because of these difficulties, inconclusive opinions occur more often with Selectric machines than with type bar machines.

In the years since 1961, modifications to the basic Selectric machine have been developed and introduced as the Selectric II, commonly called the dual pitch machines; the Correcting Selectric, which utilizes a correctable film ribbon in conjunction with a life-off tape to effect removal of a typed image from the paper; and the electronic typewriter, which employs an electronic logic board to control most of the typing operations. A number of companies, in addition to IBM, have since introduced their own single element models. With increased volume and usage of these machines, these typewriter problems will become more prevalent.

Other Mechanical Impressions

Checkwriters

Checkwriter problems encountered by the document examiner usually

5. For a detailed discussion of the Selectric typewriter, principles of operation and identification of the machine, see Ordway Hilton, "Identification of the Work from an IBM Selectric Typewriter," Journal of Forensic Sciences, 7:3 (1962), pp. 286-302. Also other articles relating to later single element models.

involve the comparison of a checkwriter with impressions on a check or the raising of a checkwriter impression by alteration. When a comparison is required, the checkwriter should be submitted to the document examiner whenever possible. In obtaining standards from the machine, the document examiner is better able to simulate the conditions under which the questioned impressions were made as well as to observe the peculiarities of the machine on a first hand basis. Differences in inking and pressure between the questioned and known specimens can be important considerations in the examination process.

When the checkwriter is not available standards should be obtained which include all of the characters on the suspect checkwriter. By so doing, it will facilitate a comparison with the numerical amount on checks not yet in hand. This may be accomplished by setting all dials at the zero position and impressing this amount, carrying the procedure through to the number nine position. Where possible, standards duplicating the amount of each questioned check available should be obtained. Securing specimens on separate pieces of paper cut to the approximate size of business check or on blank checks if available is preferred. A point to remember is that some checkwriters bear a removable prefix slug but all other parts of the machine are permanently affixed.

Checkwriters consist of casted type faces bonded to a number segment shaped in the form of a half circle and attached to an operating arm. The type faces are constructed to form either grooves or pin holes, depending upon the manufacturer. These, in turn, mesh with a platen which has been grooved or contains pin points, to form the perforated impressions. Either an inked roll is used, which passes over the type faces prior to each printing, or an inked ribbon through which the characters impress directly.

Checkwriter identification is possible because of manufacturing imperfections which may occur during the manufacturing process--casting, milling, assembly of the machine parts--and erosion of machine parts. There are few checkwriter manufacturers which aid in identification of class characteristics, especially the design of the characters.

Hand Stamps

Hand stamps come in all sizes and shapes, for many different purposes. Some are single-purpose stamp. Others are mass-produced common-use stamps. Rubber is used most commonly for hand stamps, although occasionally plastic, metal, linoleum or wood stamps will be encountered. The most common types of rubber stamps are the fixed die glued to a mount, used for signature, name, work stamps, and the like; the movable type die, used for date and numbering stamps; and the individual rubber dies which are hand-mounted into a holder.

Rubber dies are made by a process involving heat and pressure. Individual pieces of foundry type, type slugs and/or cuts are assembled into a chase which is placed in direct contact with a mat (a thermosetting plastic material) and heated under pressure to form the recessed matrix. After cooling, the matrix is placed in direct contact with a sheet of gum, and again, through heat and pressure, formed into the raised rubber dies. The dies are then cut to separate each job, trimmed as closely as possible to the impressions and then glued to the mount. As a rule, cutting, trimming and gluing are done by hand. In the case of date and numbering stamps, the rubber dies are cut into long, narrow strips and vulcanized to form a ring.

The size and design of type, and spacing and arrangement of the

material are class characteristics of rubber stamps. Individual characteristics may consist of acquired defects (those occuring from wear, age, use or misuse of the stamp) and/or manufacturing defects (imperfections which may occur in any of the above steps) (Fig. 13).

If a comparison will be required between a hand stamp and stamped impressions on questioned documents, the stamp should no longer be used and the surface protected. The document examiner should be given the stamp along with the questioned impressions.

Machine Stamps

Mechanical printing units print directly onto paper. Adding machine tapes, meter print-outs, cash register receipts, accounting machine print-outs and time cards are types of evidence produced on machine stamp machines. Machine stamps also include those devices which have a mechanical printing unit and print into a metal surface, or a plastic surface.

Printed Matter

Printed matter is examined to identify counterfeiting; the format of a form, certificate or other document; or printing from the same plate. Printed matter examination includes printing methods, the paper itself, cutting or perforating, the font, arrangement or format of the material, and printing registration or alignment. Genuine documents should always be made available for comparison with suspected counterfeit documents (Fig. 14).

Knowledge of printing materials and methods is helpful in conducting a search of a print shop or other location for evidence of certain types of printing. Items to look for are the set-up of the type chase (if it has not yet been torn down), the proof or inked impression of the type

QUESTIONED IMPRESSION

RAMON SMITH

KNOWN IMPRESSION

RAMON SMITH

RUBBER STAMP

FIG. 13. THIS STAMP CONTAINS A GROSS MANUFACTURING DEFECT IN THE FORM OF EXCESS RUBBER OR "FINS" BETWEEN LETTERS, CAUSED BY SETTING THE TYPE (IN THIS CASE EVATYPE) TOO LOOSELY. WHERE PORTIONS OF THE FINS ARE TYPE HIGH, INK IS PICKED UP AND PRINTED WITH THE STAMP. NOTE INK IMPRESSIONS BETWEEN LETTERS R AND A, M AND O, O AND N, S AND M, AND T AND H. NOTE ALSO EXCESS RUBBER ACCUMULATION ON RIGHT LEG OF R AND LEFT BOTTOM PORTION OF A, SHOWING ANOTHER MANUFACTURING DEFECT.

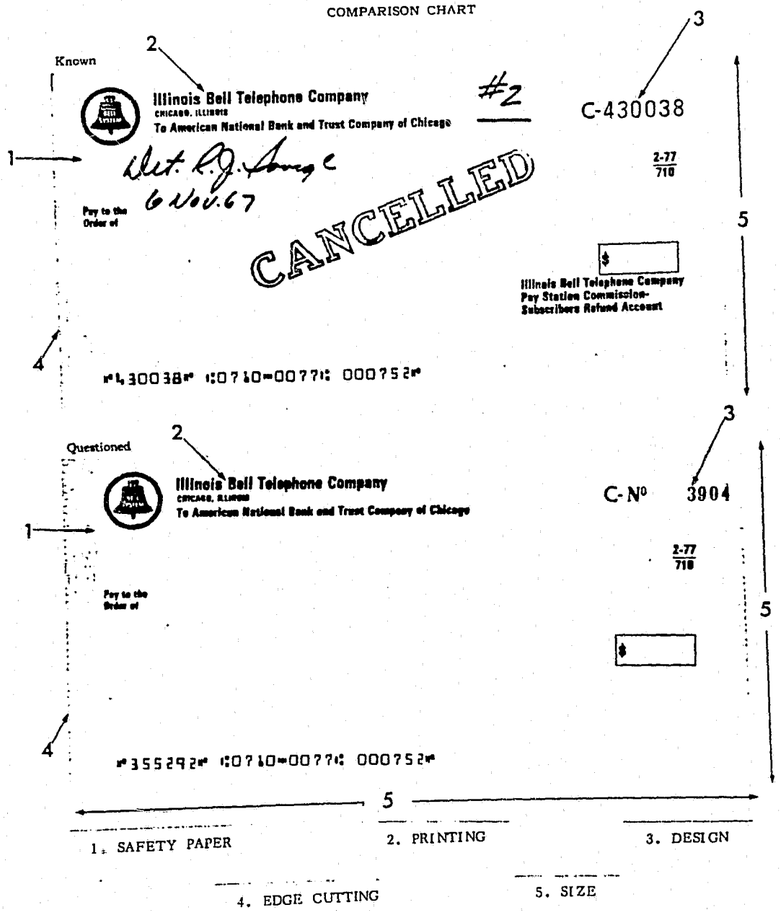


FIG. 14. THE ILLUSTRATION OF SOME POINTS OF COMPARISON BETWEEN A COUNTERFEIT AND GENUINE DOCUMENT.

set-up, the negative of the job, and the printing plate. The offset press, should be examined for an impression on the printing blanket of the questioned document. Previous impressions--even when the blanket has been cleaned and another job is in process--although difficult to see, are retained (Fig. 15). The material under investigation may be found on a wipe--off sheet (similar to a blotter). Often, copies of initial runs or copies pulled to inspect work quality can be found in the printshop waste.

Altered Documents

Documents are intentionally altered for such reasons as fraud or an attempt to protect a person's interests. Common types of alterations include increasing the amount on a check or other negotiable instrument (Fig. 16); changing the date on a letter, or legal document; changing the contents of a record book (Fig. 17); and changing information on papers of ownership, certificates and identification. Additions, deletions, substitution of material, such as a page from a grouping of papers, and obliteration of the original matter are the usual forms of alterations. The quality of any alteration is primarily dependent upon the perpetrator's knowledge of the paper and writing materials used in preparation of the original document, the availability of materials needed to accomplish alteration of the specific item, and the skill necessary to use these materials effectively.

Conversely, the discovery, decipherment or restoration of alterations involves a knowledge of the materials used in preparation of a document and a knowledge of materials and methods used to effect various types of alterations. Aids to visual and microscopic examinations include various types of light sources, such as infrared luminescence, ultraviolet,

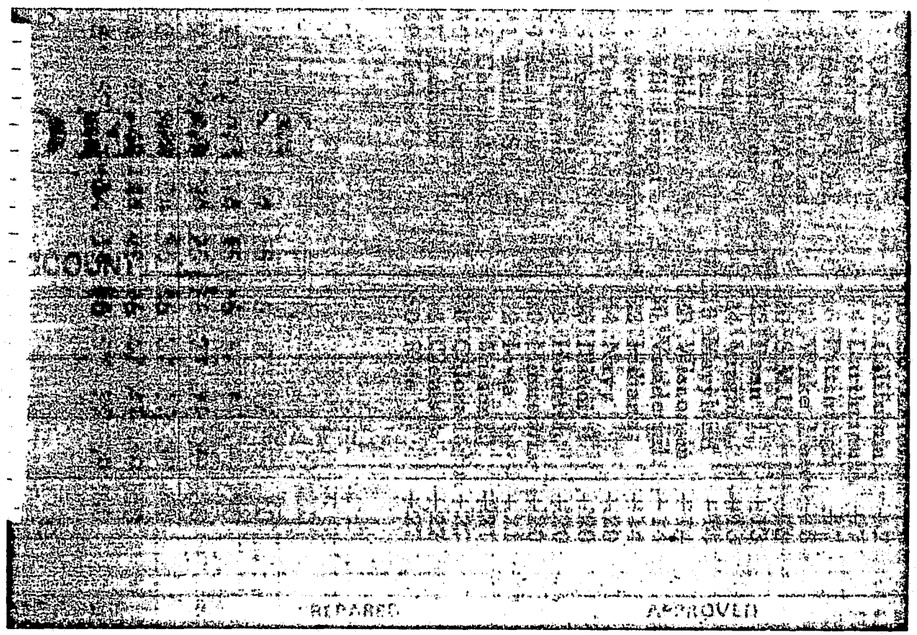


FIG. 15. THE RUBBER PRINTING BLANKET WAS FOUND IN THE PRINT SHOP AND PHOTOGRAPHED TO SHOW THE RUN OF A FOOTBALL PARLEY CARD. IT CAN BE SEEN THAT THE BLANKET WAS ALSO USED TO PRINT AN ACCOUNTING JOB.

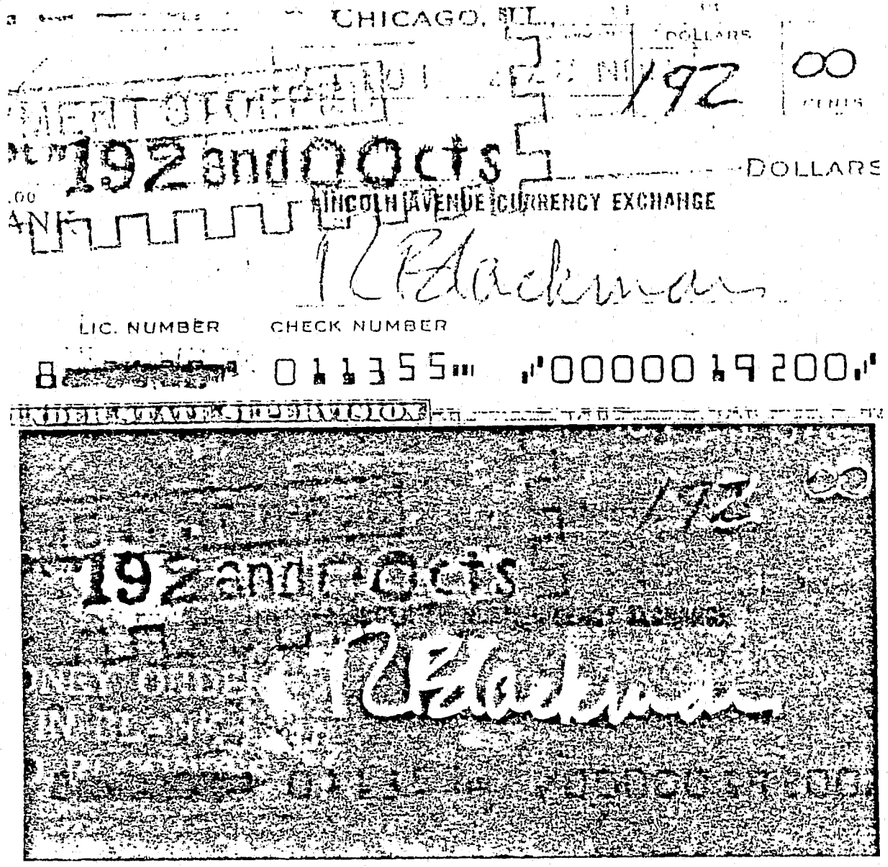


FIG. 16. A MONEY ORDER RAISED FROM $2.00 TO $192.00, PHOTOGRAPHED WITH INFRARED LUMINESCENCE.

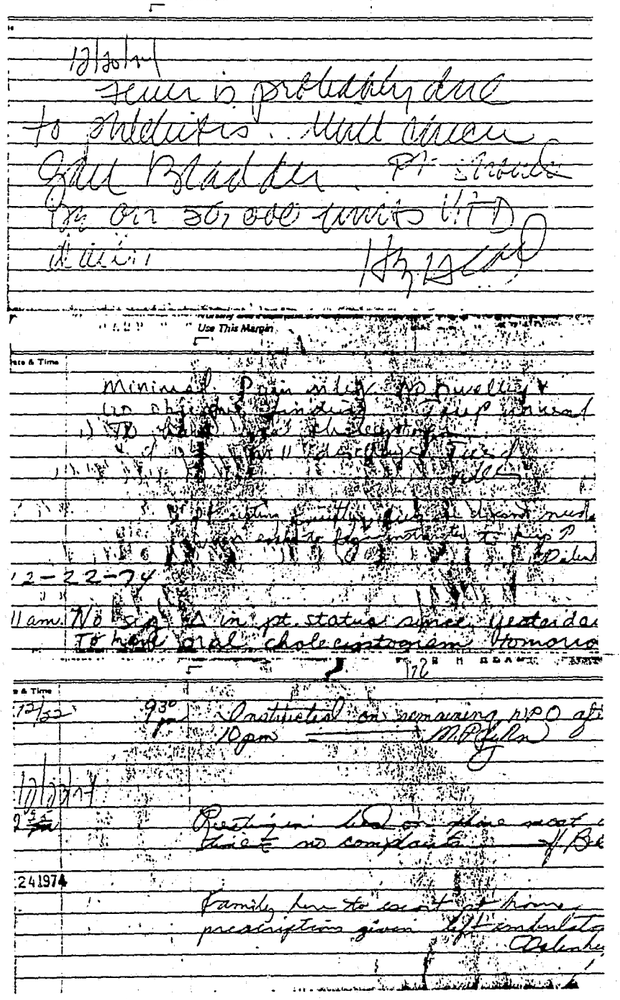


FIG. 17. IN A MEDICAL MALPRACTICE SUIT, THE HOSPITAL RECORDS WERE EXAMINED FOR ANY INDICATIONS OF TAMPERING. ONE PAGE (TOP PHOTO) SHOWED AN ADDITION "PT SHOULD BE ON 50,000 UNITS VIT D DAILY" AFTER THE FACT. THE CENTER PHOTO IS THE BACK SIDE OF THIS PAGE AND SHOWS INDENTATIONS OF THE ENTIRE ENTRY. THE BOTTOM PHOTO IS THE FOLLOWING PAGE OF THE RECORDS AND SHOWS INDENTATIONS OF THE ADDITION ONLY. ADDED PROOF IS THE DIFFERENTIATION OF THE INKS WHEN PHOTOGRAPHED WITH INFRARED FILM.
(COURTESY OF DAVID J. PURTELL, CHICAGO, ILL.)

reflected, point source and transmitted; different colored filters; and ruled plates.

Decipherment of Indented Writing

When writing occurs on one sheet of paper it causes indentations on papers beneath this page; such as where pads of paper are used. There is a close correlation between the readability of message and the depth of the indentations.

The classical method of deciphering indented writing utilizes oblique lighting, sometimes with the aid of a finely etched plate. Oblique lighting acts to create a series of contrasting shadow and highlight areas. It may be possible to make a comparison of indented writing with known standards, but only if the indented impressions are of the highest quality (Fig. 18).

Restoration of Charred Papers

The most delicate type of document evidence to handle are charred papers. Gambling cases often involve charred paper. Extreme care is needed in submitting this type of evidence to the laboratory. Charred papers should be submitted in the container in which they are found if possible. Otherwise they can be picked up with a sheet of paper and placed into a sturdy box. It is essential to keep the charred pieces intact in the event decipherable written or printed material is present. In the laboratory, charred papers are first processed to provide better handling capabilities. They may be placed between glass plates for preservation, and photographed in an attempt to intensify and decipher the contents.

Paper Examinations and Comparisons

Since almost all documents appear on paper, the examination of paper becomes an important consideration. Occasionally, the question arises as to

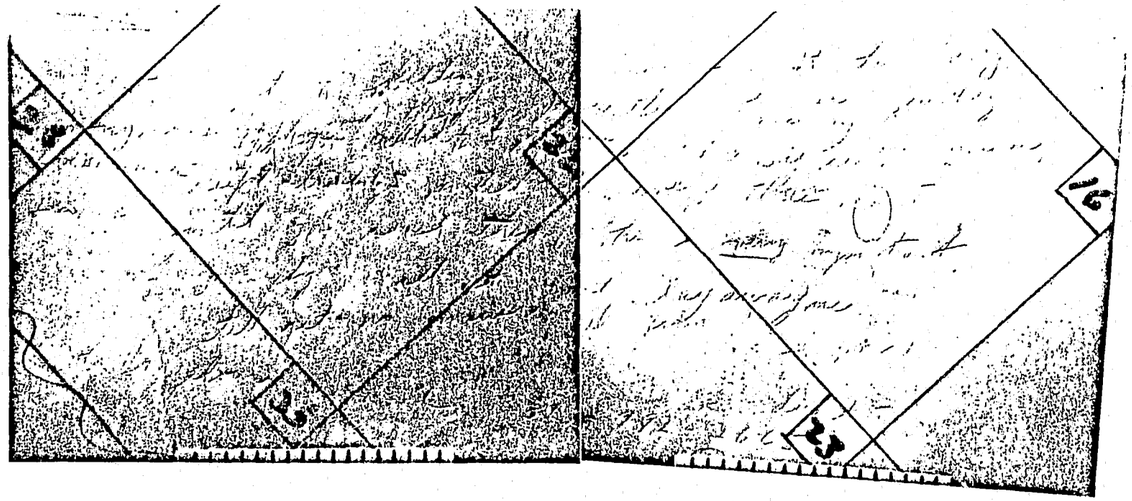


FIG. 18. THE INDENTED WRITING WAS FOUND WHILE EXAMINING A LARGE HOMEMADE CALENDAR SUBMITTED IN A HOMICIDE. THE INDENTATIONS WERE CAUSED FROM WRITING ON A SEPARATE PIECE OF PAPER LAID ON TOP OF THE CALENDAR. THEY BEGIN "NEXT GET TO KILLING OF EVERYONE BUT THE BABY---" AND GO ON TO LIST SOME DETAILS. THE INDENTATIONS WERE EVENTUALLY COMPARED AND IDENTIFIED WITH KNOWN WRITING.

whether two or more papers are similar or different. An examination and comparison of all of the physical characteristics of the papers, including their appearance under various types of light, the source of a paper and its normal use may provide sufficient data to distinguish between the papers. Chemical analysis of paper is generally not within the expertise of the document examiner, and if this need is apparent, specialists in paper analysis will be suggested.

The matching of torn or perforated edges to determine whether two pieces of paper were originally one document (Figs. 19 & 20) is another type of normal examination.

Determining the Age of a Document

This problem is generally one of determining whether a document was prepared at the time it is alleged to have been prepared. Ink dating is usually the first request made; however, there are a number of means by which a document may be placed within a certain time frame. Some papers contain watermarks which are coded as to the year of manufacture, or design changes in watermarks can indicate a date. Typewriting may be dated by the introduction of the type design or placed within a time frame by deterioration of the typewriter itself. Printed matter on a document, such as letterheads or printed forms, may be dated where design changes have been made or additional runs cause slight changes from a previous printing. Handwriting, especially a signature, may occasionally be placed within a certain time frame because of alterations previously discussed in writing due to the developmental stages and other changes in an individual's life (Fig. 21). Essentially, when examining a document to determine whether or not it was prepared at the time alleged, all materials used in the preparation of the

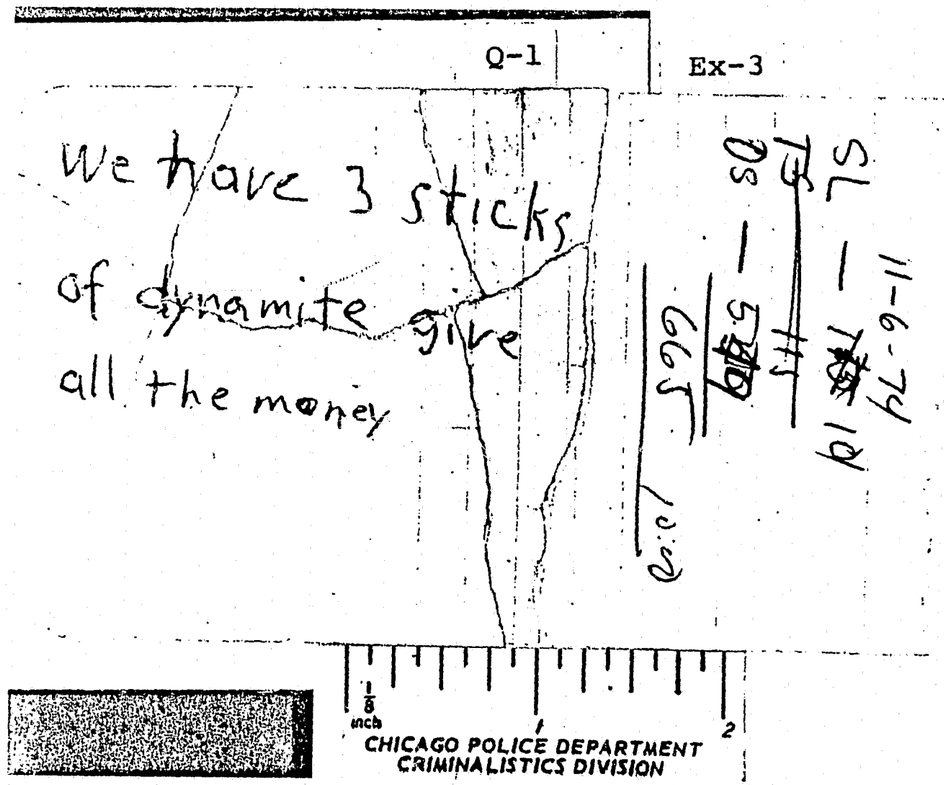


FIG. 19. THE PAPERS ON THE LEFT WERE RECOVERED FROM THE ROBBERY SCENE; THAT ON THE RIGHT FROM A SUSPECT. BESIDES A MATCHING OF THE TORN EDGE, EVIDENCE POSSIBILITIES ALSO INCLUDE THE HAND PRINTING AND LATENT FINGERPRINTS.

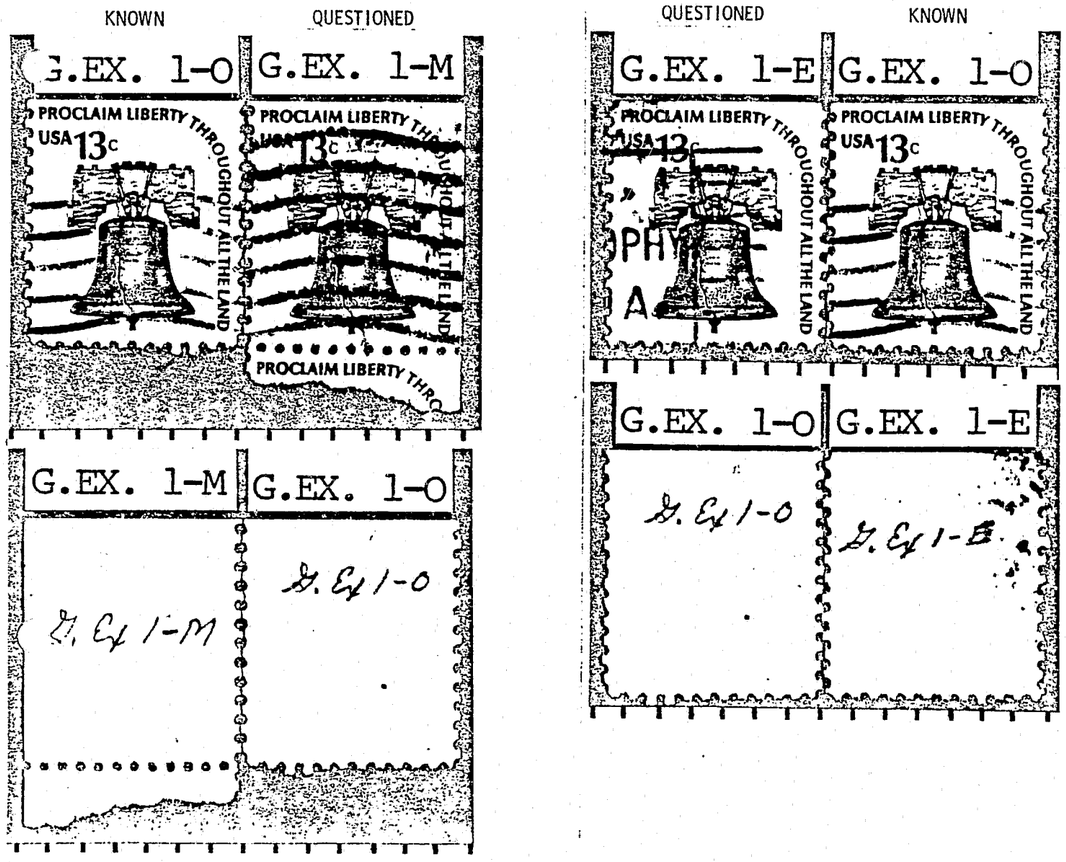


FIG. 20. SIX THREATENING AND OBSCENE LETTERS WERE MAILED TO THE VICTIM, ALL WRITTEN IN A HIGHLY DISGUISED HAND PRINTING STYLE UNSUITABLE FOR COMPARISON WITH STANDARDS OBTAINED FROM A SUSPECT. THE LETTERS, HOWEVER, COULD BE IDENTIFIED AS HAVING BEEN EXECUTED BY ONE WRITER. FINGERPRINTS OF THE SUSPECT WERE DEVELOPED AND IDENTIFIED ON TWO LETTERS. A SEVENTH HANDWRITTEN SYMPATHY LETTER WAS MAILED TO THE VICTIM AND IDENTIFIED AS THE HANDWRITING OF THE SUSPECT. IT WAS REQUESTED THAT THE POSTAGE STAMP ON THE ENVELOPE OF LETTER # 7 (G. EX. 1-O) BE CONSIDERED A KNOWN AND THAT A COMPARISON BE MADE WITH THE POSTAGE STAMPS ON EACH OF THE SIC QUESTIONED HAND PRINTED LETTERS TO DETERMINE IF ONE OF THESE STAMPS HAD PREVIOUSLY BEEN ATTACHED TO THE KNOWN STAMP. ALL CLASS CHARACTERISTICS WERE DETERMINED TO BE THE SAME. FIVE QUESTIONED STAMPS WERE ELIMINATED ON INDIVIDUAL CHARACTERISTICS; ONE QUESTIONED STAMP (G. EX. 1-M) HAD INDIVIDUAL CHARACTERISTICS IN COMMON WITH THE KNOWN STAMP. TESTIMONY WAS ILLUSTRATED WITH ENLARGEMENTS OF THE FACES AND BACKS OF THE STAMPS. IN ORDER TO PROVIDE A CLEARER UNDERSTANDING OF THE CORRELATION OF THE PERFORATED EDGES OF 1-0 WITH 1-M, IT WAS FELT THAT ONE OF THE NON-MATCHING STAMPS (G. EX 1-E) SHOULD BE DEMONSTRATED ALSO.

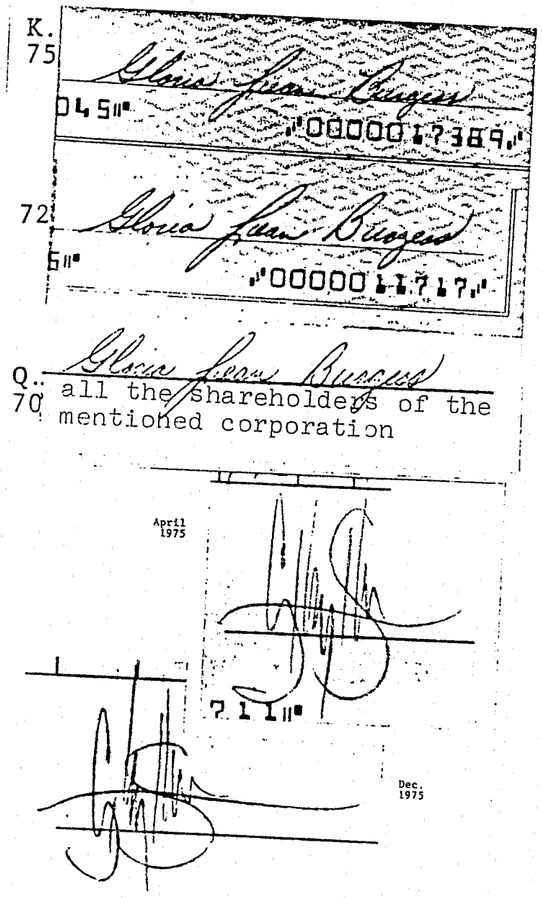


FIG. 21. IN BOTH OF THESE CASES, NUMEROUS COLLECTED SIGNATURES COVERING A SPAN OF YEARS WERE AVAILABLE FOR COMPARISON. THE QUESTIONED BURGESS SIGNATURE (BOTTOM) WAS PLACED IN A TIME SPAN PRIOR TO THE EARLY PART OF 1972, BASED IN PART ON THE BEGINNING OF THE LETTER "B" AND THE RELATIVE SIZE OF THE LETTER "e". SOME OF THE FIRM CHANGES IN THE GARY SCHUBEL SIGNATURE ARE: THE POSITIONING OF THE FIRST DOWNSTROKE FOLLOWING THE LETTER "G," THE PROGRESSIVELY LOWER "SAW-TOOTH" DESIGN OF THE REMAINDER OF THE NAME GARY, THE CHANGE FROM AN ELONGATED TO MORE ROUNDED "S," AND THE MODIFICATION OF THE FINISHING STROKE FROM RELATIVELY STRAIGHT TO AN EXTENDED LATERAL DESIGN.
(COURTESY OF DAVID J. PURTELL, CHICAGO, ILL.)

document are considered on the basis of their relevancy to the time period under investigation.

Sequence Problems

When two written lines intersect in one or more places, and it can be determined which ink lays on top, positive proof is offered of which writing was prepared first and which writing last, or the sequence of writings. Such a determination may assume importance where a document is not prepared in the usual or fixed order. Written lines in this context also include inked impressions prepared by machine or rubber stamp. Sequence of writing problems may be broadened to include the intersection of writing and folds, writing and punch holes, or writing and other disturbances to the paper (Fig. 22).

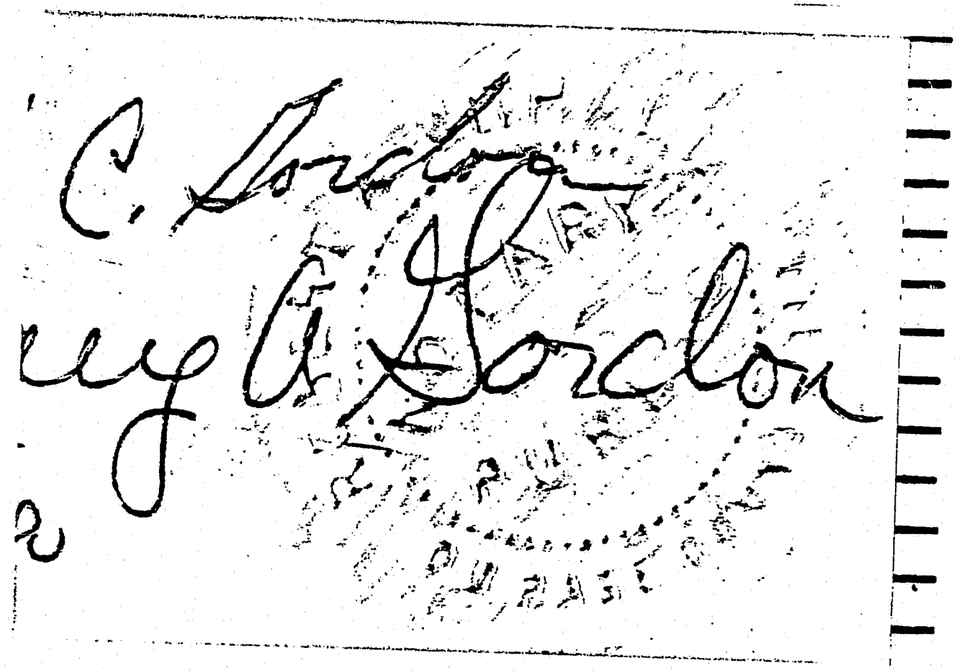


FIG. 22. A PROBLEM IN SEQUENCE TO DETERMINE WHETHER THE TOP SIGNATURE WAS PREPARED PRIOR TO OR AFTER THE NOTARY SEAL WAS PLACED ON THE DOCUMENT.

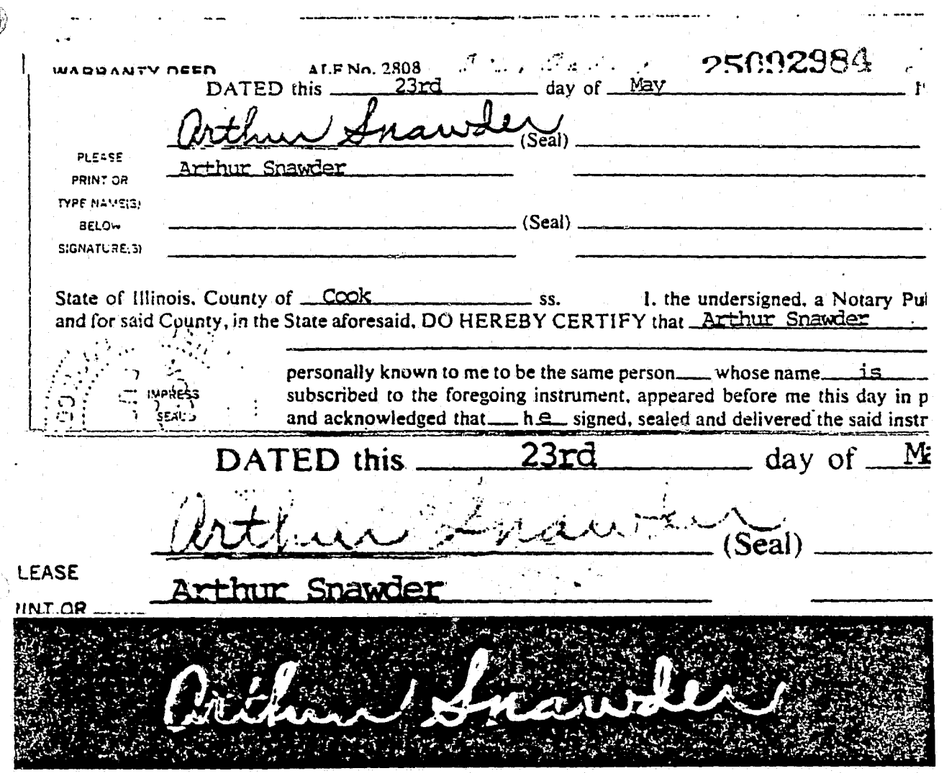
Technological Advances

When we consider that document examination involves paper and all the ways of placing a message or a mark upon a piece of paper, it can be seen that the scope and the potential of the field is large indeed. Many of the areas of document examination are specialized fields in themselves, for example, paper, printing, inks and copiers; yet, the document examiner must have a knowledge of these fields as they relate to problems involving authenticity of documents. Consider the problem of a signature on a deed in question as to its genuineness (Fig. 23). A genuine signature, from a second document, has been electrostatically copied onto the deed, then overwritten with a fiber tipped pen. One of the first clues is the extraneous or extra line beneath the printed signature line. Why is it there? A microscopic examination reveals the extraneous line is the result of a copying process. The point in this case is that with only a knowledge of handwriting the identification could be misleading. The examiner must take into account the whole document, be aware of the various methods of placing a message on a piece of paper and be able to recognize evidence of these methods. In order to accomplish these tasks, the document examiner must continually update his knowledge of fields bearing a relationship to documents.

Recently Progressing Areas

Photocopiers

Photocopiers have become so much a part of the business world today that almost every office has its own copy machine or ready access to one.



WARRANTY DEED A.I.F No. 2808 25092984

DATED this 23rd day of May

Arthur Snawder (Seal)

PLEASE PRINT OR TYPE NAME(S) BELOW SIGNATURE(S) Arthur Snawder

(Seal)

State of Illinois, County of Cook ss. I, the undersigned, a Notary Pul and for said County, in the State aforesaid, DO HEREBY CERTIFY that Arthur Snawder

personally known to me to be the same person whose name is subscribed to the foregoing instrument, appeared before me this day in p and acknowledged that he signed, sealed and delivered the said instr

IMPRESS SEAL HERE

DATED this 23rd day of M

(Seal)

LEASE PRINT OR Arthur Snawder

Arthur Snawder

FIG. 23. THE DOCUMENT HAS BEEN FOLDED TO SHOW THE EXTRANEOUS LINES FROM THE COPYING PROCESS - ALONG THE TOP EDGE AND BENEATH THE SIGNATURE LINE. THE SIGNATURE PHOTOGRAPHS ARE INFRARED - WHICH REVEALS THE PHOTOCOPIED SIGNATURE BEFORE BEING OVERWRITTEN, AND INFRARED LUMINESCENCE - WHICH SHOWS THE LUMINESCENCE OF THE COVERING INK.
(COURTESY OF DAVID J. PURTELL, CHICAGO, ILLINOIS)

Copies have become so integrated into our way of life that they are sometimes offered as evidence where the original is said to be lost, destroyed or unavailable.

Most copiers in use today are electrostatic machines which utilize plain or coated paper. Both reproduction methods offer possibilities for the fraudulent preparation or manipulation of documents. Some problems encountered in this respect are the fitting together of selected areas from original documents to form a "new" document; changing selected areas on a copy and recopying to hide the manipulation; or if all of the materials used in the preparation of the original document are available, to create a new original containing the desired changes and copy this document.

From time to time, it is useful to identify the make and model of machine used to produce a photocopy and/or the specific copier used. Because copy machines vary as to the type of paper used, the manner in which copy paper is accepted into the machine, the process by which a copy is made, the methods of "photographing" the original document, and because copy machines may develop their own peculiar defects, the possibility of identifying class and individual characteristics exists. There are in existance today over two dozen copier manufacturers producing over two hundred copier models. In the last several years, tremendous work has been done in identifying the makes, models, dates of introduction and class characteristics peculiar to numerous makes and models.[6] The basis has also been laid for determining the sources

6. James H. Kelly, Atlanta, Georgia, has pioneered this area. He has conducted numerous photocopiers workshops around the country and disseminated this information. He expects to publish the material shortly.

of individual characteristics of a copier.

Ink Examinations

Ink examinations are perhaps the most widely misunderstood area of document work, particularly with regard to dating. For many years, dating of an ink was only possible where unique changes in an ink formulation were made. For example, the introduction of ball pens in the United States in 1945 provided a date before which oil based writing inks had not been used; the change from oil based to glycol based inks in ball pens in the early 1950's provided another significant date. The introduction of the porous tip writing instruments in the early 1960's furnished yet another change in ink formulations. It must be realized that these dates are only significant in stating that a certain ink could not have been used prior to a given time; to attempt to determine how long an ink has been on the paper is generally not possible.

In recent years, strides have been made in the dating of inks largely through the efforts of chemists in the Bureau of Alcohol, Tobacco and Firearms. They requested ink manufacturers to "tag" inks with rare earth elements on a yearly basis, and in 1975 this program was put in operation with about 60 percent of ink manufacturers participating. Again, tagging only provides a date before which a certain ink could not have been used; however, since small changes are documented annually, it is now possible to narrow the time frame considerable.

Practically speaking, document problems wherein the dating of an ink is the critical factor in the case are rather unusual. More often, ink problems involve the differentiation between two or more inks on a single document. Such cases usually involve alterations or additions to an

existing document. In many cases, differentiation of similarly colored writing inks can be shown through nondestructive testing using dichroic filters, infrared luminescence, ultraviolet fluorescence, and other lighting techniques. Where these methods prove fruitless, techniques such as Thin Layer Chromatography (TLC), which involves the chemical separation of dye components, or ultraviolet spectrophotometry may be used. These last methods are destructive, requiring samples from the ink line, and obviously are not used indiscriminately.

Photography as an Examination Tool

Photography is an important tool in examining and illustrating document problems involving such areas as ink differentiation, erasures, obliterations, and chemical alterations. The document examiner makes use of various film properties, light sources, filters and cameras. Since, as a relatively small group, document examiners do not exert a critical influence on the produce market, some of their photographic equipment or setups are unique, and some of the techniques used in document photography have been adapted from other applications to help solve certain problems. For example, the technique of infrared luminescence, useful for differentiating between similarly colored inks, originally had application in the area of luminescence of minerals. It was a research-minded document examiner who realized the potential of the infrared technique to document problems.

Studies of Factors Affecting Handwriting

The commercial systems of handwriting taught since the early part of the century are still basically the same today: the letter designs and proportions have undergone no fundamental changes. What have changed in

recent years are the methods and materials used in the teaching of handwriting and the declining emphasis placed upon penmanship in the schools. Modern teaching methods generally provide little instruction concerning proper seating position, position of paper, pen position, wrist and arm movement. It appears that today's instruction allows the student great latitude in developing his own unique style. It is advantagious to the document examiner to keep abreast of changing conditions in this area which will influence the writing habits of today's students.

Factors that may affect handwriting in an entirely different sense include those caused by illness, age, a handicap, drugs or alcohol. Document examiners have studied these areas over the years and contributed significantly to the literature in this regard. More research needs to be done however. The problem is to structure and conduct longitudinal projects of statistical significance.

Evolution of the Typewriter

Within twenty years the basic typewriter has evolved through various stages--the type bar machine, the single element machine utilizing mechanical parts and the single element machine almost entirely controlled by electronic circuit boards. Along the way, the single element machine was interfaced with a control unit to create a new concept termed word processing. In its simplest form, a word processing system consists of a typewriter and a magnetic card or magnetic tape control unit. The typewriter is adapted with an interface to the electronic control unit. Text is entered at the typewriter keyboard and automatically recorded, via the electronics, on a magnetic card or tape. Control or code keys, located on either the keyboard or control unit, instruct the system to perform various operations of editing

and formating. The completed text, in its revised form, is then automatically played out on the typewriter.

IBM introduced word processing in the 1960's. When other manufacturers entered the market in the early 70's, all but one utilized the I I Selectric typewriter as the Input/Output (I/O) unit, adapting the machine to be compatible with their control units. Then, in 1974, Xerox introduced their 800 word processing system which utilized a unique single element printer as the I/O unit. The print mechanism was a simple plastic or metal disk, termed a Daisy wheel, with 96 petals, each of which carried a print character. The unit was capable of printing bi-directional lines, making it a faster typing system than that used by IBM. Only a few years later practically all office word processing systems were being manufactured with the printer unit instead of the IBM typewriter as the output unit.

Between significant changes in typewriter and word processing systems, numerous models and modifications of the basic units are marketed. It is a challenge to the document examiner to keep abreast of the typewriter field, both domestic and foreign, as well as to reassess the identification potential of the various new units and systems.

The newest identification challenge in this area will lie with the printers. The wheel-type printers, primarily Diable and Qume, are still relatively new and few such problems have been encountered to date. Another type of printer marketed in the last few years is the IBM Ink Jet printer, a non-impact system wherein the characters are formed by deflecting charged ink droplets onto the printing surface. The printing is recognized by the dot formation of the letters, characteristics of matrix printers, and the appearance of the ink on the surface of the paper. Other types of impact printers such as the drum or chain printers, usually associated with computer

or high-speed printing, are also being studied as potential document problems.

Sequence Problems

Until recently, the most effective method of examining the sequence of written lines has been done microscopically with controlled lighting. It is a difficult problem and, in many cases, no solution is possible. The recent development of a lifting technique, using KromeKote paper, offers an advancement in ball point pen sequence determination. Enhancement of the method for aged ball pen writings is a more recent contribution in this area.

Instrumental Analysis

The most important tools of the document examiner, in addition to his perceptiveness, are microscopes, photographic equipment, light sources and reference files. Handwriting problems still constitute the majority of the document examiners cases and for these, a microscope will be an important aid. However, handwriting problems may often involve other types of document evidence, such as alterations, the presence of indented impressions, and paper examinations, and in many of these areas, research has provided better methods of detection and illustration.

One of the newest instruments in the arsenal of the document laboratory is the Electrostatic Detection Apparatus (ESDA), which is used for the detection and development of vary faint indented impressions on paper. Heretofore, very faint indented impressions could rarely be deciphered by the classical method of examining and photographing with oblique light. With the ESDA, the document is placed on a metallic vacuum plate, covered with a thin transparent film which is electrostatically charged and then

developed with a toner powder. The principle of detection lies in the variation in voltage potential between the recessed and nonrecessed surface of the charged film as patterned by the document. The document remains unaltered and the developed film is preserved with a plastic covering (Fig. 24).

Instruments and techniques developed for other fields and purposes are constantly reviewed to determine if they may be useful in examining document problems. Studies have been conducted using spectrofluorometry on inks, the scanning electron microscope on sequence problems, and the laser on alteration problems, to name a few.

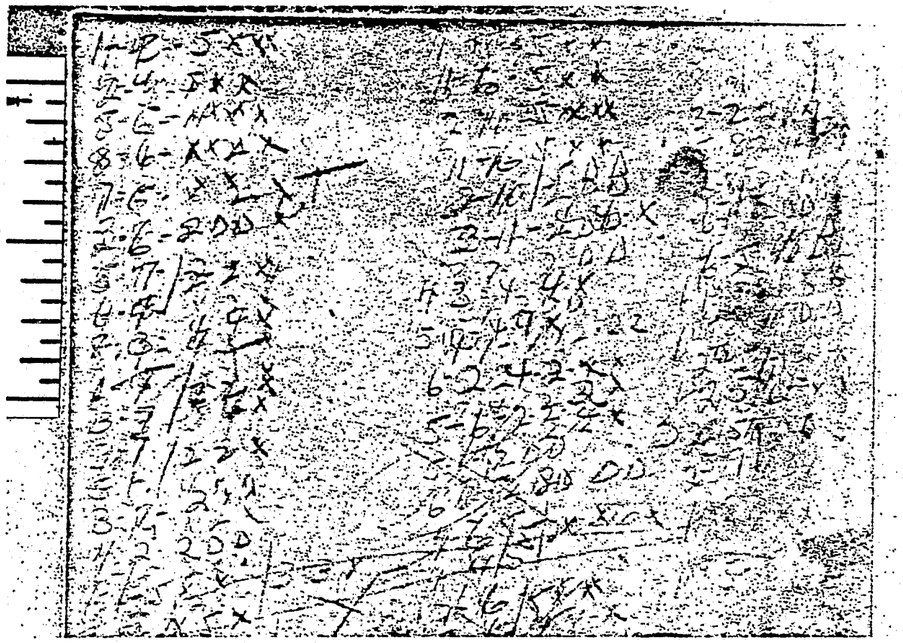


FIG. 24. THE DEVELOPED TRANSPARENT FILM FROM THE ESDA.

Qualifications of the Forensic Document Examiner - Certification

Qualifications of specialists in forensic document examination have been, for the user, more difficult to assess than qualifications of specialists in other professions where more guidelines have been established and published. It can be established, for example, that a lawyer at least has earned a law degree and passed the bar examination or that a Certified Public Accountant has a degree in accounting and has passed a required examination. In the field of document examination, proof of a minimum level of knowledge and competency has been more difficult to support and evaluate. Long cognizant of this problem, the American Board of Forensic Document Examiners, Inc., (ABFDE) was organized in 1977 to provide, in the interest of the public and the advancement of the profession, a program of certification in forensic document examination. The initial sponsors of the ABFDE are the American Academy of Forensic Sciences and the American Society of Questioned Document Examiners.

Certification is based upon the candidate's personal and professional record of education, training, experience, and achievement, as well as on the results of a formal examination. The ABFDE requires of applicants an earned baccalaureate degree, the documentation of a full-time two-year training period and the completion of an additional two year of full-time independent document work in a forensic document laboratory recognized by the Board, and references of three Forensic Document Examiners attesting to the person's professional qualifications for certification and high ethical character. In addition, the applicant is required to be engaged

in the full-time practice of document examination and to be involved in appropriate professional activities. If these and certain other requirements are met, the applicant then undergoes a series of practical, written and oral tests based upon the broad range of problems frequently encountered in document examination.[7]

The first group of qualified applicants was certified in October of 1978. Between then and April 1981, 212 document examiners have been certified through this program and are designated as Diplomates of the American Board of Forensic Document Examiners. A directory of diplomates in forensic document examination as well as diplomates in other forensic specialities has been published by the respective Boards and distributed through the Forensic Sciences Foundation. The current directory is a 1982 edition.

Certification by the ABFDE is a guide to the user of document examination services that a person has met certain requirements of education, training and experience in this field.

Sufficiency and Training of Qualified Document Examiners

Beginning in the 1970's and continuing into the 1980's, crime laboratories, whether on the federal, state or local level, find that qualified document examiners are among the most difficult of technical personnel to recruit. The most probable reason is the number of new laboratory systems established in the 1970's which had an immediate need for qualified personnel. Most document examiners are trained in government laboratories to fill

7. Brochure - American Board of Forensic Document Examiners, Inc., May, 1978

personnel needs; the training period covering a minimum of two years. As long as the training of document examiners remains an apprenticeship program, there may continue to be a shortage of qualified personnel.

A problem in this area that needs to be addressed is the number of inadequately trained or untrained people offering service in handwriting and other document-related problems. This is true of many private practitioners as well as a few persons working for governmental agencies. Perhaps because most people can write and therefore feel familiar with handwriting, this discipline seems to create more instant experts than any other; in many cases, alleged expertise is based upon little more than a correspondence course, three-week seminar, two-hour lecture, attendance at a scientific meeting or the reading of a document book. This is a problem of serious proportions and if it continues without check, it is possible that the courts will begin to treat document testimony as second class evidence.

Research by the Document Examiner

Because document examiners are a relatively small group, they do not exert an influence on the product market to the extent that products or equipment are designed primarily for their use. Research and design are expensive services and unless these costs can be recouped in the final product, few are interested. A recent exception has been ESDA, discussed previously, which was manufactured specifically for deciphering indented impressions.

Consequently, the document examiner is required to do his own research to develop new tools and better techniques to solve both new and old problems. The problem, of course, lies in the amount of research which can be accomplished with the inevitable limitations on time and money. Since

almost all document examiners are full-time practitioners and carry full caseloads, it is difficult to find sufficient time to pursue a problem even when one is faced with it daily. There is general consensus among document examiners that some way should be found to allow research-oriented practitioners the time to pursue worthy projects which ultimately benefit all.

END NOTES

1. Journal of Criminal Law, Criminology and Police Science, Vol. 60, No. 4, Dec. 1969.

2. For a detailed explanation of the makeup of the form, see Purtell, David J., "Handwriting Standard Forms", Journal of Criminal Law, Criminology and Police Science, Vol. 54, No. 4, 1963, pp. 522-528.

3. Gilbert v California, 388 U.S. 263, 87S. Ct. 1951 (1967) Schmerber v California, 384 U.S. 757, 86S Ct. 1826 (1966)

4. For this and other typewriting problems, document examiners maintain an extensive typewriter reference file covering domestic and foreign styles of type, dates of introduction of type styles, dates of changes in type styles and design modifications of typewriters.

5. For a detailed discussion of the Selectric typewriter - principles of operation and identification of the machine, see Hilton, Ordway, "Identification of the Work from an IBM Selectric Typewriter", Journal of Forensic Sciences, Vol. 7, No. 3, 1962, pp. 286-302. Also other articles relating to later single element models.

6. James H. Kelly, Atlanta, Georgia has pioneered this area. He has conducted numerous Photocopiers Workshops around the country and disseminated this information. He expects to publish the material shortly.

7. Brochure - American Board of Forensic Document Examiners, Inc. May, 1978.

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Admissibility of expert evidence to decipher illegible documents. 11 A.L.R. 3d 1015.

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GLOSSARY

Questioned, unknown, disputed, etc. - A document or the elements of a document in dispute.

Known, standard, exemplar, specimen, etc. - those documents or elements which can be verified as genuine and are, therefore, valid comparators with questioned material.

Collected writings	Writings prepared at a time and for a purpose other than the present investigation.
Dictated writings	Writings prepared specifically for the purpose of comparison with questioned writings in a given case or investigation.
Difference	A consistent personal habit repeated throughout a writing and, significantly, not found in the comparison writing or capable of being explained through the comparison writing.
Disguise	A deliberate attempt on the part of the writer to alter his natural habits of writing in order to make identification of the writing impossible.
Elimination	An opinion that the author of a known writing did not execute a questioned writing.
Identification	An opinion that the author of a known writing executed a questioned writing.
Natural variation	Slight modifications of the basic form throughout successive specimens of one individual's writing.
Simulated forgery	The attempt to copy in a freehand manner the characteristics of a genuine signature (or handwriting) either from memory of the signature (or writing) or from a model.
Spurious forgery	A signature prepared primarily in the author's own handwriting with little or no attempt to copy the characteristics of the genuine writing.
Traced forgery	The outlining of a genuine signature from one document onto another document by means of carbon, indentations, or the like.

FORENSIC TOXICOLOGY

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EXECUTIVE SUMMARY

The responsibility of all forensic scientists, including forensic toxicologists, to both the criminal and civil law courts is increasing and is now of unprecedented scope. Functional definitions are given:

> Toxicology is defined as the study of the adverse effects of chemical substances on living systems, and forensic applies the results and opinions from such studies in a medicolegal context.

A forensic toxicology case involves one or more individuals, living or deceased, in which it is suspected that drugs, poisons, or other xenobiotics may have played a role, wholly or in part, in the circumstances immediately surrounding a case into which there is legal inquiry.

The forensic toxicologist not only functions as a professional, but also has certain academic and professional qualifications. Today's toxicologists must be analytical chemists of the highest order and also biomedical scientists, such as pharmacologists, if they are to meet both the technical and professional demands made on them by their forensic science colleagues and the contemporary justice system.

By these definitions, there are too few forensic toxicologists and not enough university graduate level training programs to fill the need. One answer would be a program in which undergraduate chemists would undertake study in a biomedical science to doctoral level, followed by employment as a postdoctoral fellow in forensic toxicology to gain practical experience and make some research contribution leading to membership in the American Academy of Forensic Sciences and eligibility for Board certification. Unfortunately, recognized education-training programs of this type do not

exist except on an occasional ad hoc basis. Further, there is a critical need for continuing education seminars and workshops conducted by university-based central research laboratories in support of service laboratories and their professional staff.

Technical developments in the analytical chemistry aspect of toxicology have resulted in laboratory data which is often beyond the toxicologist's ability to interpret as to cause and toxic effect. It is a critical issue and a challenge to forensic toxicologists to become knowledgeable about the biochemistry and physiology relevant to their science and to understand more about the fundamentals of the pathology resulting from chemical insult. A redress of this imbalance is urgently needed but it seems unlikely unless appropriate support is provided for those toxicologists who are relatively free of a daily case load and are able to devote themselves to research.

Forensic toxicology is not a luxury to the courts in 1982; it is required and essential. However, it belongs in the administrative system where it may be free from the bias generated by alliance with either side of the adversary system. Toxicology laboratories are expensive to create. Most have developed slowly and, although many have adequate capital equipment, such as analytical instruments, they are often manned by poorly qualified personnel in compromised environments who bear heavy case loads to be paid for with inadequate appropriations from local or state government budgets.

The rationale and technical principles of analytical toxicology are described. The scope of the analyses cannot be universal but rather must be defined within practical limits or in a particular case context. Typical specimens, their value and use in the analytical scheme permit the toxicologist to detect, identify and determine quantitatively the concentration of drugs, metabolites, and poisons to defined limits of accuracy, precision and sensitivity. This is rarely done in routine cases; there is an urgent

need for work in this area, for improved proficiency testing programs, and for the development of quantitative reference methods. Although the technical means to achieve superb analytical data are available, programs to ensure creditable, technical quality in forensic toxicology service laboratories are urgently needed.

The practice of forensic toxicology in the 1980's will be far from ideal, and is unlikely to make full use of available new laboratory techniques or current knowledge of toxicity mechanisms. Several projects, however, could be undertaken which would significantly improve current practice and provide better opportunity for toxicologists to take advantage of new knowledge. A series of monograph critiques could be prepared which would distill much of the biomedical research findings into terms relevant to toxicology. Similarly, development and publication of quantitative reference analytical methods is quite practical and would greatly assist quality assurance in service laboratories. Support for a store of reference standards of guaranteed purity is needed and should include stable isotopes of the most common drugs, metabolites and poisons.

Reference analytical and interpretive data will continue to be the single most essential item to forensic toxicologists. Despite this assertion, only in Western Europe is any attempt being made to bring rational uniformity to these data banks. Some effort is being made to study and publish systematic approaches to analytical toxicology for forensic purposes and to provide carefully evaluated chromatographic reference data, but the work is painfully slow and unsupported by the United States. This could be easily rectified.

The forensic toxicologist, in partnership with pathologists and other forensic scientists, plays an increasing professional role as an ombudsman

of public health issues, and this new dimension to the profession will grow to almost frightening proportions before the end of this century. The alarm which is rightly felt in the profession can only be assuaged by increasing the knowledge base from which toxicological opinions are rendered. Marvelous though the techniques of forensic science are, the intellectual foundation which alone gives them meaning cannot be allowed to wither, otherwise the profession will withdraw on itself and shirk those very issues which its practitioners' training and expertise should fit them to understand.

Nature and Scope of the Discipline

If the broadest possible definition of toxicology is taken - that it is the study of the adverse effects of chemical substances on living systems and that forensic toxicology applies the results and opinions from such studies in a medicolegal context - then it follows that toxicology is neither new nor limited to man. It also becomes clear that its practice in the 20th century is increasingly concerned with the adverse effects of synthetic substances such as drugs and industrial chemicals, both directly and indirectly, through the society and ecosystem of which mankind is an integral part.

It is striking that the word toxicology itself is derived from the Greek use of bows and poisoned arrows in the arts of war and hunting. From ancient times through the Middle Ages, the understanding and application of poisons was developed through knowledge of their chemistry, and indeed, the chemical extraction and identification of a poison in man was usually sufficient evidence of its culprit role. In these simpler times arsenic, mercury and organic plant alkaloids such as atropine and digitalis were regarded as unnatural constituents of man's normal biochemical makeup. Today, arsenic and mercury are almost environmentally ubiquitous and are accepted as part

of man's normal body burden, and analogs of digitalis are among the most widely used drugs for the treatment of cardiac illness. Their presence now is no longer evidence of toxicity, and may, in fact, represent the contrary.

The earliest toxicologists were necessarily chemists, and following the examples of Mathieu Orfila (1839, first extracted arsenic from human organs), Jean Sevais Stas (1850, developed a method for the extraction of alkaloids in postmortem tissues, and the quantitation of metals in human organs), F. J. Otto (1856, modified Stas' method to include non-alkaloidal substances) and Wilhelm Autenrieth (1905, wrote the first practical book on toxicology, The Detection of Poisons and Powerful Drugs). They developed analytical techniques by which they could isolate and identify the offending poison postmortem literally for all to see.

This trend, of the analytical chemist becoming the toxicologist-pathologist, and applying his skills to the postmortem investigation of suspicious death, and thereby providing coroners with evidence for establishing cause and manner of death, continued well into the 20th century, up until about the Second World War in Western Europe. Perhaps the last of the great pathologist-toxicologists was Sir Bernard Spilsbury in Great Britain, but the trend towards the professional forensic chemist-toxicologist was well underway in both Europe and North America at the time of his death after the war. An increasing number of organic and analytical chemists had become fascinated with the difficult problems involved in the extraction and identification of poisons from biological specimens, and the rise of the pharmaceutical industry, with its profound influence on medicine, gave impetus to their task as dedicated medicinal chemists produced new chemicals (drugs). Many of these drugs, while providing dramatic improvements in health when used by knowledgeable and prudent physicians, were potentially harmful.

A generation of analytical toxicologists, whose principal mentor was Dr. Alexander O. Gettler, the first forensic toxicologist of the Medical Examiner in New York City, began in the 1930's and is still with us today. These scientists were almost exclusively concerned with the extraction identification and ultimately the quantitation of poisons in autopsy specimens. They were part of the team which was responsible for the medicolegal investigation of sudden and unexplained deaths. Very quickly the detection of alcohol in the context of driving impairment and highway safety became a part of their professional responsibility, and soon quantitative demonstration of the poison was admitted into court as prima facie evidence of cause and effect. With this historical background, it is difficult to deny that a qualified toxicologist must also be an exquisitely skilled analytical chemist.

In an almost historical parallel, pharmacologists have inquired into the mechanisms of drug action, of how chemicals used in the treatment of illness actually work. This pursuit inevitable leads to an appreciation of the adverse or toxic effects of drugs and some of the gross biochemical and physiological alterations they can cause. The study of the pharmacological basis of therapeutics (classically set forth by Goodman and Gilman in The Pharmacological Basis of Therapeutics,) was their metier, and many of these biomedical scientists specialized in the study of toxicities and earned the title toxicologist. It is interesting that it was a forensic problem that eventually brought the chemist-toxicologists and pharmacologist-toxicologists together. The catalyst was the need for reasonable legislation concerning the problem of alcohol, the drinking driver and highway safety. The chemist possessed the expertise to assay ethanol accurately and precisely in biological samples such as blood and urine, and invent and test devices for the determination of alcohol in breath. The pharmacologist, on the other hand,

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4 OF 5

understood the kinetics and metabolism by which ethanol disturbed the body biochemistry and physiology resulting in the physical impairments recognized as intoxication. They also appreciated that the manifestation of symptoms of intoxication were not always necessary for an underlying, but nonetheless debilitating toxicity to be present.

The chemists came to the world of toxicology from industry, pharmaceuticals, and from government laboratories such as customs and excise, where they analyzed and assayed contraband including narcotics; the pharmacologists came from biomedicine and pharmacological research laboratories and provided the means of understanding toxicity as related to the identity and concentration of poisons in animals and man. This 20th century partnership, sometimes easy and sometimes strained, has matured to a point where, under the pressure of social needs (for example, the problems of drug misuse and abuse, and chronic toxicity from passive exposure to environmental poisons or from life-long use of therapeutic agents) it has melded, so that today there is at least a cadre of toxicologists who are wholly educated and professionally experienced as both analytical chemists and pharmacologists and who devote their intellect solely to problems of toxicology. These problems include especially difficult matters which must be adjudicated through litigation in the courts, areas properly the province of forensic toxicology.

Unfortunately, there are too few of these professionals and there is little sign that the current limited university programs will add to their number significantly in the near future. Although forensic toxicology is perhaps most widely applied as a part of the postmortem investigation of sudden, unexplained deaths, the forensic scientist today is called upon to support legal inquiry into a very broad variety of criminal and civil matters

in which drugs or poisons may be involved. It is the task of the forensic toxicologist to detect, identify and determine the concentration of poisons in biological specimens, and to express the analytical data as an opinion about toxicity within the circumstantial limits of any particular case problem.

Both areas of analytical chemistry and pharmacology have in recent times become more complex and difficult than would be expected from their historical precedents. The macabre, beautiful art of homicidal poisoning may have become unfashionable in the era of the crude, violent handgun, but accidental and suicidal poisoning, as well as unintended chronic toxicity resulting most often from the ingestion or exposure to multiple drugs or chemicals, have grown at an alarming rate during the past twenty years and now present almost insurmountable problems for the forensic toxicologist. In the same period, the chemist has benefited most from extraordinary technological developments in scientific instrumentation which now permit the isolation of drugs and poisons and their bio-transformation products, and allow for their absolute identification even when only infinitesimal amounts are present. However, the understanding of the toxic effects of these xenobioties has lagged far behind the ability to isolate and identify them. As social, medical and legal demands increase, the disparity between the remarkable analytical skills and the intellectual capacity to interpret the data thus accumulated becomes an ever greater block to meeting these demands. This is the main problem facing the profession today and one which most forensic toxicologists are seeking to resolve.

CURRENT CAPABILITIES AND LIMITATIONS

The inseparable components of a modern forensic toxicology operation required if expert opinions are to be provided to the courts are: the scientists themselves, professionals with the intellectual capacity and experience to form rational opinions from the laboratory data generally produced by technical colleagues or assistants; adequate laboratory space in an appropriate location; and laboratory equipment, the chemicals and instruments, tools of the toxicologist's trade. Lastly, financial support is required, for an operation which provides valued professional services but does not generate direct revenues.

Most forensic toxicology laboratories are associated with state or local government services. These are usually either medical examiner-coroner offices or state attorney general or county attorney departments. Some are even directly associated with police departments, sheriff's offices or departments of public safety. Historical development is again responsible for this unfortunate situation. Although scientist-expert witness should not be an advocate for either side but should present his own scientific opinions properly based upon facts in the case as a "Friend of the Court," he is all too often seen and treated as accusatorial and in league with the prosecutor. This is almost inevitable when it is recognized that until very recently most inquiries and requests for services came to toxicologists through the investigating, prosecuting arm of the law. The advent of public defender systems and aggressive legal investigation in pursuit of civil litigation has begun to change the public perception of the forensic scientist's role. The clear independence given to most medical examiners by statute has also helped these forensic toxicologists who are

part of the medicolegal investigation team. A few forensic toxicologists are able to work from a laboratory based in a university medical center which at least provides them the opportunity to preserve their professional neutrality, but there are all too few such groups in North America.

In contrast, it must be clearly recognized that the forensic toxicologist cannot be, and is not, an isolated professional; he is part of a team which at the very least involves an investigator, a forensic pathologist, and probably a medical examiner or coroner, and certainly at least one attorney. Virtually no case can be resolved on the basis of toxicology data alone, without the integration of the circumstantial evidence, the medicolegal autopsy findings and microscopic, histological studies, and an understanding of the exact legal question that is posed in the case. To this important extent, toxicology is simply one piece in a jigsaw puzzle; the whole picture cannot be seen without the toxicological piece, that piece does not represent the entire picture either. Ideally, toxicologists and their laboratories should be either associated with the medical examiner or coroner's office, the Department of Justice (but entirely divorced from any direct connection with lay enforcement), or in a university medical center setting. Whenever possible, forensic toxicologists should be administratively placed within the bureaucracy so that no direct association exists with either side of the adversary system.

The establishment of a new toxicology laboratory, from blueprint to operation, is not inexpensive. All too often, science in the service of public health and law has been short-changed and viewed as a luxury to the courts rather than a fundamental necessity to the administration of justice. In consequence, most of the forensic toxicology service laboratories in the United States today are inadequately supported and without the minimal complement of staff and equipment. A forensic toxicology laboratory investigating

2-3,000 cases per year in support of a medical examiner, a drinking and drugged driver program, and drug abuse enforcement, as well as perhaps jail and probation surveillance work, cannot fulfill its duties without a chief toxicologist fully qualified with several years experience, and at least four or five technical laboratory staff, including graduate level analytical toxicologists. Quite apart from the usual chemicals, glassware and laboratory bric-a-brac essential for any analytical work, there is a need for costly and sophisticated scientific instruments, to include spectrophotometers, scintillation and gamma counters, gas chromatographs and high pressure liquid chromatographs, a versatile mass spectrometer and the inevitable minicomputers, microprocessors and calculators for statistical analyses and control. To equip such a laboratory costs between $1/2 - 3/4 million, but the pressure to compromise must be resisted. The sensitivity and specificity required in contemporary analytical toxicology, quite apart from the taxing legal demands made by the courts for accurate factual evidence, makes these instruments essential and has rendered classic steam-distillations, most testtube color reactions and volumetric chemistry inadequate and obsolete.

Forensic toxicology laboratories which have teaching and research responsibilities (and these are very badly needed) have even greater requirements, particularly regarding the level and experience of their personnel. They should be able to accept visiting scientists from service laboratories and postdoctoral candidates who have graduated in pharmacology or biochemistry or chemistry and who wish to be trained to Board certification level in forensic toxicology.

It has been said that forensic-analytical toxicology is one of the easiest things to do badly and one of the most difficult things to do well.

When compromise cuts too deeply, the negative result will be vastly disproportionate to the small cuts or equipment denials made in good faith by a budget conscious bureaucrat. It should be recognized that during the past ten years the Federal Law Enforcement Assistance Administration (LEAA) has done much to support the physical improvement of existing facilities for forensic toxicologists, and the National Institute on Justice has recognized the need to support research in this applied science. Much of this valuable effort has gone for nought, however, because there has been so little support for training new forensic toxicologists or for encouraging mature biomedical scientists to enter this challenging field. In consequence, mass spectrometers and other equipment bought with federal largess, although vitally needed, have not been used to their full potential. Training and research programs in support of forensic toxicology nationwide are desperately needed and, until improvement occurs, current knowledge will be only slowly assimulated and applied, new knowledge and techniques will be neglected, and the courts will be inadequately served.

Almost all toxicological investigations proceed in two stages. The first involves the analytical chemistry which provides the data upon which the second depends, namely interpretation of that data within a particular case context. These two stages will be dealt with separately.

There are five sequential steps to be considered in the first stage of analytical toxicology: 1) the selection and acquisition of appropriate biological specimens for analysis, 2) extraction of any drugs or poisons and their metabolites which may be present in the specimens, 3) separation of the extract into its individual constituents, 4) identification of the separated constituents, and finally 5) the quantitation (the amount or concentration present) of any drugs, poisons and their metabolites. The

analysis always proceeds in this order although some steps may be omitted (e.g. extraction, in direct immunological testing) or partially integrated (e.g. separation-identification in gas chromatography-mass spectrometry); each step is dependent upon the preceeding steps, and defined controls are necessary for each step if the final result is to have acceptable quality assurance which can withstand the rigors of legal examination.

What is a forensic toxicology case? It is any case involving one or more individuals, living or deceased, in which it is suspected that drugs, poisons, or other xenobiotics may have played a role which, wholly or in part, accounts for the immediate circumstances surrounding the case, and in which there is legal inquiry. The forensic toxicologist begins by trying to state clear questions which address the case problem he will attempt to answer. Without this clear statement of purpose and question, the toxicologist will be involved in little more than a fishing expedition or data gathering exercise which is unlikely to prove rewarding or relevant to the legal inquiry. It is, therefore, extremely important that lawyers and also pathologists discuss the case in sufficient detail with the toxicologist to allow these questions to be formulated. A list of common case types and typical questions associated with them are listed in Table 1.

Perhaps the most common cases are those which involve postmortem investigation where the cause and manner of death are at issue. Figure 1 is an example case data form, or questionnaire depending upon its use, which provides for the type of information which is very important for the toxicologist so that appropriate analyses can be designed and the analytical data adequately interpreted. Certainly there are routine analyses which are carried out in almost every case; for example, the quantitative determination of alcohol is a requirement in every case no matter what the circum-

TABLE 1

COMMON CASES

CASE TYPE	QUESTION	LITIGATION
SUDDEN DEATH AT HOME	WERE DRUGS OR POISONS INVOLVED? CAUSE AND MANNER OF DEATH.	CRIMINAL: IF HOMICIDE CIVIL: INSURANCE CLAIMS PHARMACEUTICAL CO.: SUED
FATAL ACCIDENT AT WORK	WERE ALCOHOL AND DRUGS INVOLVED? WAS DECEASED CULPABLE IN OWN DEATH?	WORKMAN'S COMPENSATION AWARD. SUIT AGAINST EMPLOYER
FATAL ACCIDENT IN CAR	CAUSE OF DEATH-ALCOHOL AND DRUGS? ACCIDENT OR SUICIDE?	CRIMINAL-AUTO-HOMICIDE CIVIL - INSURANCE CLAIMS
NON-FATAL ACCIDENT IN CAR	WAS THE DRIVER RESPONSIBLE? INFLUENCED BY DRUGS? WAS MEDICATION TAKEN AS PRESCRIBED?	CRIMINAL, CIVIL SUITE - PERSONAL INJURY, PROPERTY DAMAGE
CRIME COMMITTED - DEFENDANT HAS DRUG USE HISTORY	DID DRUGS INFLUENCE THE DEFENDANT'S BEHAVIOR?	DIMINISHED RESPONSIBILITY?
DEATH OR ADVERSE DRUG REACTION UNDER CARE OF A PHYSICIAN.	WHAT DRUGS-METABOLITES CONCENTRATIONS? INTERACTIONS?	MEDICAL MALPRACTICE SUITS AGAINST PHARMACIST AND PHARMACEUTICAL CO.
UNEXPECTED DEATH IN HOSPITAL	WAS DRUG TREATMENT APPROPRIATE. CAUSE OF DEATH? THERAPEUTIC MISADVENTURE OR NEGLIGENCE?	MALPRACTICE CLAIMS CRIMINAL, CIVIL, MEDICAL BOARD HEARINGS.
AIRCRAFT ACCIDENT	WERE ALCOHOL AND DRUGS INVOLVED? DID THEY INFLUENCE THE PILOT? WAS IT AN ACCIDENT?	CIVIL - LIABILITY PERSONAL INJURY, PROPERTY DAMAGE INSURANCE CLAIMS

FIGURE 1

CASE DATA

AGENCY NO. _____

DATE OF DEATH _____

OFFICIAL CAUSE OF DEATH (C.O.D.) _____

1. MANNER _____ 2. C.O.D., DRUGS _____ 3. DRUG(S) NAME _____

HX OF DECEASED

4. OCCUP. _____ 7. RACE _____ 11. PSYCH. HX. _____

5. AGE _____ 8. WT. _____ 12. SPECIFIC _____

6. SEX _____ 9. MED. HX. _____

10. SPECIFIC _____

CIRCUMSTANCES OF DEATH

13. SUSPECTED DRUG(S) _____ 19. OTHER MEDS. _____ 25. TERM. SYMP. TYPE _____

14. PROPR. FORM _____ 20. LOCATION _____ 26. SPECIFIC _____

15. DOSE UNIT _____ 21. TIME (L.S.A.D.) _____

16. SOURCE _____ 22. SUIC. INDIC. _____ 27. TREATM. _____

17. RATIONALE _____ 23. SPECIFIC _____ 28. TYPE _____

18. ROUTE _____ 24. TERM. SYMP. _____ 29. DRUGS _____

PATHOLOGY & TOXICOLOGY*

30. AUTOP. _____ 34. APPR. C.O.D. _____ 38. ETOH _____

31. TIME (D.-A.) _____ 35. GROSS _____ 39. DRUGS & ETOH _____

32. SPEC. COND. _____ 36. MICRO _____

33. BLD. SOURCE _____ 37. DRUGS ONLY _____

DRUG	BLOOD	LIVER	URINE	BILE	(mgs) + G. CTN.
ALCOHOL					

*CONCENTRATION IN MICROGRAMS/ML or MICROGRAMS/GM

*G. CTN = TOTAL OF DRUGS IN USE

stances, who the victim, or of what sex, age, or occupation. On the other hand, the brief facts of medical history and possible therapeutic use of drugs would immediately signal the need for particular analyses. If the victim was an epileptic, for example, it would be very important to determine if commonly prescribed anticonvulsant drugs were in the blood at the time of death at effective concentrations. In another case, this class of drugs may be of no significance. Forensic toxicology is a puzzle and it must be approached as an investigation requiring a high degree of scientific suspicion and logic. It would be inappropriate for an analytical toxicologist to give first priority to snake or spider venoms if he works in a typical large city office in the United States, however, he would be remiss if a broad range of commonly prescribed drugs known for their potency and potential toxicity were ignored. The scope of a given analysis then is first defined by the circumstances prevailing in each case, the known history of the victim and on the basis of local experience. The local experience must also include what is normal in the population. Miners may carry a heavy burden of metals, coast dwellers eating shellfish may have elevated arsenic levels, farmers and those in rural areas may be exposed to particular pesticides, and all without any overt, acute toxicity. The detection of these "normal" substances in local populations must obviously be interpreted with great care.

Clearly, the scope of the toxicology investigation cannot be universal, but the analytical methods available in a modern forensic toxicology laboratory should be able to detect, identify and determine the concentration of the major pharmacological classes of drugs, such a sedative-hypmotics, analgesics including narcotics, anti-anxiety agents or tranquilizers, common drugs of abuse, stimulants and associated psychoactive drugs, and the most

common therapeutic agents over-the-counter at the drugstore and those which are prescribed long-term for chronic illness, such as the anti-hypertensives anti-convulsants, and cardiovascular agents many of which have only a narrow concentration margin between therapeutic effectiveness and toxicity. In addition, elements, pesticides and herbicides, and, of course, the alcohol, carbon monoxide and cyanide must be included. In a few cases this catalog will not be enough and there is, therefore, a need for a few reference laboratories skilled in the unusual as well as the routine; for example, the analysis of toxic, thermal degradation products of synthetic construction materials which burn in major fires are of growing importance in both criminal and civil law when an exact cause and mechanism (smoke inhalation, carbon monoxide poisoning, cyanide poisoning, asphyxiation, heat blast) of death must be determined.

Other special cases include aircraft accidents, some industrial accidents, and deaths in which multiple drugs, each taken in relatively low dosage, are suspected. The most important criterion in any case, however, is that the scope and analytical sensitivity limits of the complete analytical scheme be defined so that negative results, especially, have a clear meaning.

Not all drugs and poisons can be detected in all biological specimens at any particular time and, therefore, the choice and availability of samples for analysis are crucial. Obviously specimens from living individuals are limited and generally only blood or plasma and urine are available. Occasionally gastric contents, cerebral spinal fluid and saliva may be available and useful. Although in many special circumstances, when a particular poison may be suspected unusual autopsy specimens may be required, such as fat in pesticide cases and spleen in cyanide poisoning. There are five specimens which should be taken in all cases: blood from a major

vessel and blood from a peripheral vessel, gastric contents (total), liver, bile (total) and urine (total). Often lung, brain and heart tissue are useful and in the absence of gastric contents or urine, small intestine contents and kidney tissue are valuable substitutes respectively.

As a general approach, the peripheral blood sample will be used to detect ethanol, methanol, acetone and isopropanol, and other volatile hydrocarbons usually by gas chromatography without prior extraction. Some other direct testing of blood and urine specimens for major groups of drugs such as opiate narcotics, barbiturates, and amphetamine and its derivatives can be accomplished by either enzyme or radio immunoassay methods. These methods are rapid, very sensitive, and in some applications, remarkably specific, but their principal value lies in the quick determination of a negative result, that is the absence of particular drug groups in the specimen tested. Positive findings must always be confirmed by a different independent method.

Blood, urine, gastric contents or tissue homogenates can be extracted with organic solvents such that drugs, poisons and metabolites are isolated from the biological matrix according to their chemical character; strong and weak acids, strong and weak bases, neutral compounds and some amphoteric substances. Absorption columns and even charcoal are also used to effect the extraction of drugs from the specimens, but organic solvent systems are still the most popular. The extracts will, of course, contain some naturally occurring substances such as cholesterol, fatty acids, triglycerides, creatinine and the like, and the subsequent separation stage of the analysis must be able to differentiate between any drugs and their metabolites and these natural biochemicals.

Chromatography in its various forms is the technique used almost

universally to accomplish separation of these extracts into their individual constituents. Although imaginative manipulation of chromatographic systems by many analytical chemists has permitted their use for partial identification, it must be emphasized that all chromatography is first and foremost a separation technique; secondarily, it is very important in the quantitation of the separated drugs; and only lastly, should it be considered as a method of identification. In general, thin-layer chromatography (TLC) with a wide variety of developing reagents is used to separate extracts of urine and gastric contents, and gas liquid chromatography (GLC) and high pressure liquid chromatography (HPLC) are used with a variety of detectors for blood and tissue extracts. Each of these chromatographic techniques has its own advantages and limitations. For example, GLC by definition can only separate compounds which can be volatilized and carried through the separation column as a gas, but with selective detectors and long capillary columns it can be supremely sensitive and provide remarkable discrimination between closely related compounds. In contrast, HPLC will separate non-volatile compounds and very large molecules which are very difficult to separate any other way. By judicious use of these different forms of chromatography, analytical toxicologists can today separate very small quantities (in the nanogram range, ng/ml i.e. one billionth of a gram) of almost every drug or poison of interest.

Some information concerning the identity of the isolated substances can be gleaned at this stage of the analysis from consideration of their chemical behavior and their retention times; that is, the time it takes for the substance to pass through the chromatographic separation column, but these data are not definitive. Several compounds may belong to the same chemical class and behave similarly, and chromatographic systems cannot

completely differentiate every compound on a single column. Defining the discriminating power and the sensitivity of any chromatographic system is critical to its intelligent application in toxicology. Although historically ultraviolet and visible spectrophotometry have been staples for the analytical toxicologist, and are still used for some barbiturate determinations, carbon monoxide and colorimetric assays, they have in general been superceded by the chromatographic and immunological techniques already described. As a minimum then, any forensic toxicology laboratory should have the means to effect column or solvent extractions, and gas chromatographs with flame ionization, nitrogen selective and electron capture detectors, and a high pressure liquid chromatograph with variable wavelength ultraviolet absorption and fluorescence detectors, as well as thin-layer chromatography capability.

Information leading to the identity of the isolated compounds is gathered sequentially as the analysis proceeds through extraction and separation, but final unequivocal identification lies with either a composite of data concerning the chemical character of the compound so that all other reasonable possibilities are eliminated or by use of mass spectrometry. By the first method the extraction behavior of the compound in question will be known and also its chromatographic characteristics and its retention times (and for some compounds immunological behavior in a test system.) This information will lead to a presumptive identification by comparison with known reference data. Additional confirmation is usually obtained by forming known chemical derivatives of these suspected compounds and comparing their chromatographic behavior with prepared reference standards.

Mass spectrometry (MS) is a technique which allows for the controlled degradation of a molecule such as a drug or organic poison, under electron

bombardment and/or chemical reaction such that the pattern of molecule fragments, separated according to their masses, can provide a "fingerprint" of the whole molecule. By comparison with reference standards or libraries of reference containing mass spectra of compounds pertinent to toxicology, an identification can be made. The mass spectrometer is qualitatively the most specific and the most sensitive instrument available to the forensic toxicologist. It has the additional very important advantage that it can be engineered in conjunction with GLC, and even HPLC, so that the chromatographically separated compounds can be transferred into the mass spectrometer source for immediate analysis. Most mass spectrometers used by analytical toxicologists are, in fact, GLC-MS instruments.

The degree of time and effort that will be applied to absolute identification of isolated compounds will depend on their importance in the case and the ultimate legal consequences of the toxicological data. A case in which it is only important to know whether the victim had taken a cardiac-glycoside agent as prescribed by a physician would not require the specificity which even a barbiturate identification would make necessary if the drug had been quantitatively determined in a driver's blood and he was subsequently charged with auto homicide; then the difference between the drug being identified as phenobarbital or secobarbital would be extremely important.

All of the techniques already described can be used as quantitative methods providing appropriate reference standards, controls and internal standards for the analysis. GLC and HPLC are the most commonly used techniques for quantitative determinations. The choice, however, in any particular case will depend in part upon the sensitivity requirement; for example, it is not at all unusual for one drug to be pharmacologically active at nanogram/milliliter concentrations and another to be important only at high

microgram/milliliter concentrations, at least a thousandfold difference. The analyst must also decide just how accurate and precise the quantitation needs to be. Since drinking drivers are charged by law according to minimum concentrations of alcohol in the blood, it is important that findings be as accurate and precise as the analyst can produce. In contrast, if gram quantities of a drug are assayed in postmortem gastric contents and are clearly indicative of a large acute overdose, it is of little importance whether the quantity is determined accurately to the nearest one-hundredth of a gram or not.

The foregoing are the four major stages of any forensic toxicology analysis together with their most commonly used techniques and methods. A clear understanding of the quality of the data generated is a prerequisite to any sensible interpretation of the findings in terms of particular questions and circumstances in the case.

The ultimate quality of the results hinges critically on every stage of the analysis beginning with the type and condition of the biological specimens available. It would be simply inappropriate to analyze gastric contents for a drug that was known to be used intravenously, and bile would be a specimen of first choice if drugs or poisons known to circulate through the liver into the bile and the gastro-intestinal tract were of interest. Many drugs concentrate in particular organs or, like heroin, may be excreted rapidly into the urine which this specimen to a level of first importance. Toxicological analyses may be compromised because of the condition of the specimens, due to fire exhumation, and exposure. The best means of preserving specimens is to freeze them in chemically-clean glass containers. Plastic containers of any kind are inadequate and often cause analytical problems because plasticizers and associated chemicals in the plastic will leach into

the specimens and confound the analyst. Blood samples should be preserved with an antibacterial and anti-enzyme agent such as sodium fluoride to prevent degradation of drugs and metabolites during storage, or, indeed, production of compounds such as ethanol. Urine should be kept weakly acidic and frozen during storage. The importance of these protocols cannot be overemphasized.

The sensitivity limit of each method, both qualitative and quantitative should be known and stated by the analyst so that a report which indicates that no drugs were detected in the sample has meaning with respect to some minimum detectable value. Generally, in forensic toxicology, sensitivity limits should at least be within the concentration range known to be therapeutically effective for a drug, and within the known range of body burden values for other chemicals, except for those few which are known poisons at any value. The accuracy and precision of quantitative methods should be determined and documented in every laboratory. Standard deviations or coefficients of variation of 5-10 percent at a reasonable toxicological concentration are acceptable for most chromatographic procedures, even though some methods can achieve much better than this. These principles together with instrument calibration and reference control analyses are the very essence of quality assurance for the total analytical system and the resulting data.

Forensic scientists, be they pathologists, document examiners or toxicologists, have the responsibility to express opinions concerning the role of drugs or poisons in a particular case, but must base that opinion on credible data. The toxicologist's professional credibility is the final yardstick by which his opinions will be judged. Logical opinions, capable of clear, rational explanation depend crucially upon the demonstrable quality

of the data from which they are drawn.

Unfortunately, this ideal situation does not exist in many places. This is not because forensic toxicologists are derelict in their professional responsibility or because generally they are incompetent, but rather because they, like other forensic scientists, are to some extent victims of the systems they serve. In most medical examiner's offices, for practical, political and administrative (including budget) reasons, not all bodies are autopsied, and not all that are autopsied are subjected to toxicological examination, and of those that are referred to the toxicologist, not all are replete with proper specimens nor can they all be subject to exhaustive analysis. In short, forensic toxicology practice in the United States is far from ideal in 1980 and unless major changes occur with respect to the importance which society, and the courts in particular, place upon this science, there is little prospect that it will improve. Many laboratories are not adequately equipped and, even if they are, many are not occupied by fully qualified toxicologists. In addition, the sheer workload of the busiest urban laboratories often precludes the development of adequate basic reference data about methods and their limitations as well as the introduction of new techniques into the laboratory.

It is not to be suggested that money for bigger and better analytical instruments is the answer nor is that what the justice system demands or expects. The courts and lawyers expect professionalism from forensic toxicologists and opinions which are defensible, that is, that will withstand rigorous scientific inspection and legal cross-examination. They should not be impeachable.

The best assurance is the toxicologists themselves; they should by virtue of their academic training and professional experience be credible to the

courts. Ideally, the toxicologist should have had training and experience that has led to Board certification in forensic toxicology through written examination and inspection of credentials. This certification should be current and based upon periodic reexamination and continuing education activities. To reach this stage of professional maturity, it is recommended that chief forensic toxicologists be drawn from the ranks of doctoral (PhD) scientists who have graduated from university with organic chemistry (analytical) and a biomedical science, preferably pharmacology. They should then have experienced at least one year of postdoctoral training in an existing forensic toxicology laboratory and made some research and development contribution to the scientific literature during that time. During or at the end of this time, they should be eligible for acceptance into the American Academy of Forensic Sciences, Toxicology Section, and then be prepared to undergo Board examination. This educational and professional approach is, of course, analagous to other professions which have subspecialties, such as medicine and law itself. This system could not be put into practice immediately because there are simply not enough laboratories which could be approved as training facilities for postdoctoral candidates and there are few university graduate level programs teaching forensic toxicology.

There are other important matters which bear on the quality of toxicology case reports. Development of state-of-the-art quantitative analytical methods, no matter how sophisticated, are needed so that routine methods used in the laboratory can be evaluated and understood fully with respect to their limitations. At present, quantitative mass spectrometry techniques offer the best approach for reference methods; several such procedures do exist and have been published but many more are needed desperately. Acceptable protocols to determine accuracy are

not in general practice. When a reference standard solution is made of any drug in any matrix, it is very important to know its true value within statistical tolerances if it is to be used to calibrate an instrument or to prepare analytical controls. With few exceptions, fundamental wet-chemistry methods are not available for toxicological analyses. The best alternative is to have the reference solution analyzed by more than one completely different method, including a reference type procedure if it exists, and by more than one analyst in different laboratories. This is a laborious approach but it does not have to be done often. It cannot be ignored indefinitely as it is today because the quality of all quantitative analyses depend directly upon that reference standard solution. This practice is, of course, part of any quality assurance protocol in an analytical laboratory but external proficiency testing is equally important.

Proficiency testing provides externally prepared, simulated case specimens containing drugs or poisons in known concentrations, to be sent to forensic toxicology laboratories for analysis. These analyses permit the toxicologist to evaluate their own analytical results against those of other participants. The data can be used as a laboratory management tool to improve performance by indicating that a particular method is not working well at which time advice and assistance can be sought. The data can be used as a convincing reference for laboratory excellence, and most importantly, it can be used to determine very clearly areas in which education or research and development are required. This last aspect, of course, again leads to the need for reference laboratory centers in university settings at which workshops, seminars, and other educational activities can be made available to practicing toxicologists. These do not exist today; they are urgently needed. Forensic toxicology proficiency testing lags far behind its clinical-medicine counterpart. Although recently supported by the National Institute on Justice, it is in its infancy,

barely one year old.

In summary, although the analytical methods available are marvelous by contrast with practice just a generation ago, programs to ensure creditable, technical quality in forensic toxicology laboratories are urgently needed, and above all an integrated effort to educate and train professional toxicologists who can truly fulfill the needs of the courts should be given the highest priority.

DEVELOPING AREAS

Beyond the concepts of "new scientists and new standards of practice for old" and the need for reference laboratories with research and education responsibilities, there are several very difficult, technical, not-so-easy pieces within the toxicology puzzle.

The most rapidly developing area in analytical toxicology is the immunological technique in which antibodies have been raised against a particular drug or drug class or poisonous chemical so that they can be used as test reagents for their complementary compound. These antigen-(drug) antibody reactions depend upon either an enzyme, or a radioactive or fluorescent marker for their detection. They are rapid, direct testing methods with exquisite sensitivity but complete control of the selectivity of the antibody for the substance(s) for which it was designed is not yet achievable. Development of these immunoassays is very costly and involves more than a little scientific art. Ultimate selectivity, that is unique specificity, is not necessarily always the most desirable goal. Ironically, through new techniques of genetic engineering, monoclonal antibodies uniquely specific for a single drug or chemical have been raised in research laboratories and are technically much more certain in their preparation. What is really needed are antibody reagents tagged for detection which have predesigned, known reaction characteristics. When this is possible, antibodies with broad cross-reactivity can be made for screening purposes, multiple antibodies can be prepared as single reagents so that different classes of drugs could be detected in one test, and monoclonal antibodies will be used to detect single species. Much work is yet to be done before these techniques will take their appropriate place in forensic toxicology.

Among the analytical instruments which are developing to the benefit of toxicologists are improved mass spectrometers, and, of course, microprocessors and computer-data systems. Technologically, the computers and microprocessors are here and now but their application and best use in the toxicology laboratory needs much evaluation. Particularly their role as easy substitutes for the human brain needs to be carefully considered if it is the human which must present and defend the laboratory results in a court of law. This is not a trivial problem, and how best to quality control computerized analyses and reference data banks involves questions which are only just being asked. Without doubt, the role of mass spectrometers will grow, especially in the area of reference quantitative methods but some difficulties continue even as the sophistication of the instruments increases and the price of workhorse models decreases.

About ten years ago, some forensic toxicologists seized upon mass spectrometry as their answer to unequivocal qualitative identification of drugs, metabolites and other chemicals which they extracted from biological tissues. This was without question a major advance, but the fascination with this one aspect of GC-MS capability has over the years militated against its broader uses. When full spectra of the compound being analyzed are generated from GC-electron-impact-MS, the classic fingerprint pattern is produced which represents a unique profile of molecular fragments for that particular compound. When this pattern is compared and matches in detail that of a known reference compound, certain identification can be made. Although reference data banks, both in book and computer storage forms, have grown, they are incomplete for the toxicologist. More importantly, the reference spectra are not generated under standard instrument conditions agreed upon by the profession, nor are they presented uniformly. There is at last some

sign that toxicologists recognize the need to address this serious issue, but nothing significant has been accomplished to date to rectify the situation.

Possibly the greatest power and value of GC-MS lies in its ability to perform quantitative analyses at sensitivity levels generally beyond any other technique, and with great accuracy and precision. To use the instrument in this way, however, requires considerable experience and technical skill currently lacked by many toxicologists. Some headway has been made in the past two or three years through the encouragement and support of the National Institute on Drug Abuse (NIDA) Research Technology Branch, and under their auspices, a monograph of quantitative GC-MS methods for drugs of abuse has been published. This work has formed the basis for additional quantitative methods development, and there should be a steady stream of publications in this area in the near future.

A lack of available, appropriate internal standards for GC-MS assays has also inhabited methods development. Ideally, deuterated stable isotope analogs of the drugs and metabolites to be assayed should be used as internal standards, although they are not absolutely necessary in all cases. These isotopes are chemically identical to the drug to be analyzed except that their mass has been increased by a known increment through the addition of deuterium atoms to the molecule. The synthesis of these stable isotopes requires the skill and expertise of organic chemists and is very expensive (for example, 100 mg of an isotope may cost $7-10,000). On the other hand, about 10 mg of such an isotope can last an analytical toxicologist a lifetime. Consequently, there is a considerable exchange mart in these substances and they are jealously guarded when acquired. The need for a store of these compounds of known chemistry and purity is essential to the future of

analytical toxicology, and NIDA has begun a limited program to fill this need. Particular drugs of abuse and substances which are not otherwise available from commercial sources have been synthesized under contract for NIDA, who will now make small quantities available to biomedical researchers and toxicologists on special request. More needs to be done, however, on a much broader base if quantitative GC-MS techniques are to be used to develop reference methods in toxicology as previously discussed.

Perhaps the most important rapidly developing area lies in international cooperation between toxicologists in sharing their individual knowledge and improve the basis from which they interpret their analytical data. Since 1963, the International Association of Forensic Toxicologists (TIAFT) has fostered projects to critique chromatographic practices and recommend changes. Additionally, they have supported publications of scholarly monographs on the toxicology of specific substances and classes of drugs, but most of all, they have compiled and distributed toxicology case reports together with a description of the laboratory methods that were used to investigate each case. These cases now number a few thousand and form one of several case data banks which are used as references by toxicologists to interpret a particular case at hand. In fact this procedure of comparing the findings in a new case to be interpreted with the existing body of case-lore and case reports, together with what is known about the pharmacology, metabolism and pharmacokinetics of the drug in normal therapeutic circumstances, is the way in which almost all cases are interpreted today. Clearly, this is a crude empirical approach and is the weakest link in the five stages of the toxicology investigation.

There have been, however, considerable advances in the last five years towards a fundamental understanding of some of the mechanisms by

which adverse drug and chemical reactions occur. This has not been accomplished by toxicologists but rather by their partners in science, the pharmacologists and biochemists, and to some extent by pathologists in basic research. Under the impetus of cancer research and the need to understand the controlling factors in malignant cells and their biochemical response to chemotherapeutic agents, much has been learned about toxic bioactivation triggered by drugs. Also, the growing concern about drug interactions, multiple drug usage and the potential for resulting iatrogenic illness, has stimulated research and scientific reports on mechanisms of toxicity. Significant new understanding about the function of the human immune system, and intracellular component of hepatocytes has resulted. These rapidly developing areas are of great importance to forensic toxicologists as they strive to interpret their analytical data in terms of adverse physiological and biochemical response, and from this knowledge express opinions about cause and effect. No one has yet undertaken to critique and distill much of this information into terms relevant to toxicology. This must be done soon if the practicing professionals in the field are to realize the full benefit of these research findings.

CRITICAL ISSUES

Ultimately, there is really only one critical issue and that is, can mechanisms of toxicity uniquely characteristic of particular drugs and poisons be demonstrated in man? If there is cause and effect, can the forensic toxicologist, alone or with colleagues from allied professions, especially pathology, provide proof sufficient for legal adjudication? It is the mission and the professional responsibility of forensic toxicologists to do so whenever possible, but unfortunately there are relatively few classes of drugs and chemicals for which clearly defined mechanisms of action and toxicity are known. There are few for which lessons can be demonstrated chemically or pathologically in biological specimens from living individuals or even postmortem. It is the critical issue and challenge to the forensic toxicologist to become knowledgeable about the known biochemistry and physiology of their science and to understand more about the fundamentals of pathology which results from chemical insult. An endeavor to set down in monograph form current knowledge in this area must be undertaken soon before it falls by the wayside. Generally, toxicologists do not understand much of pathology, but they should as it relates to toxic manifestations, and similarly, forensic pathologists are generally woefully ignorant of the many recent and rapid advances made in toxicology and should, therefore, be able to rely with confidence upon their professional partner for advice and consultation.

The problems of defining and demonstrating toxicity strike at the heart of the relationship between laboratory results and actual toxic events, in a science in which the technical capacity to produce data has outstripped our ability to understand its forensic significance or interpret its toxicological message. A redress of this imbalance is urgently needed, but it seems unlikely that forensic toxicologists will do so unless appropriate research support is forthcoming for those who are relatively free of the daily case travail and are able to devote themselves to research.

Precious little research, save in the applied analytical area, is being done by forensic toxicologists in the United States. This is not an indictment of individual toxicologists because they are harnessed to heavy case loads and unsupported by any central research laboratories. They make progress by culling the analytical biochemistry literature and the allied biomedical sciences to pick up what they can and apply it as they have time. It is then the basic and applied research being done by chemists and biomedical scientists in universities who, through their publications and presentations at scientific meetings, assist the forensic toxicologists. But within their own profession there is no such supported, organized activity. There are only a few forensic toxicologists who have primary appointments in universities and who have a mandate to conduct research of this type.

One unfortunate outcome of this situation has been the premature promulgation of law and regulations before adequate scientific data and knowledge is available to support their enactment. For example, there are many statutes which state that it is illegal to drive an automobile on the highway while under the influence of a drug. These laws are weakly enforced, in part because being under the influence of a drug to such an extent that normal driving ability is impaired almost defies definition on the basis of current scientific knowledge. It is known that millions of drivers take drugs legally under the supervision of a physician for illness but they are not

over-represented in highway accidents. How then is toxicity and legal infringement to be defined in these circumstances? Certainly there are gross example cases, but just because the analytical toxicologist can assay drugs and metabolites at very low concentrations in small blood samples taken from drivers does not mean that the all important fifth stage of toxicology (interpretation) automatically follows. Virtually no research, except a few ad hoc studies, is in progress on this problem, but it is critical and until it is addressed, the courts will continue to look askance at toxicologists when these cases come before them for adjudication or in civil litigation. Perhaps the best example of this dilemma is the OSHA (Occupational, Safety and Health Act) regulations which permit only limited concentrations of a long list of chemicals to be allowed in the atmosphere of the workplace or in the general environment. These concentration limits were selected in the first place more or less on an arbitrary basis but have continually been challenged in courts so that they undergo almost constant revision. This is wrong; legal controversy is causing the revision when it should be research results on the toxicity of the substances which influences the law and provides a creditable basis for toxicologists who testify in the courts.

There are several areas in forensic toxicology which need immediate study and critical review so that synopses of current knowledge can be passed on to practicing forensic toxicologists. These include the role of drugs in highway safety which has already been discussed, understanding toxicity which can result from inappropriate medical use of drugs which gives rise to medical negligence and malpractice cases. Very few patients ever receive only one drug. Usually, at least three, and sometimes as many as ten or fifteen, drugs may be prescribed for one patient. Even if

each drug has only one major metabolite, obviously a very complex analytical problem must be solved before any interpretation as to adverse effects can be inferred. Adverse drug interactions are constantly reported in the medical literature, but many are anecdotal cases and not substantiated by appropriate laboratory studies. Those which are documented by pharmacologists and for which the mechanism is known are too few relative to the case reports and this knowledge also needs to be distilled into a concise and useful form for forensic toxicologists.

This same knowledge impinges upon many civil cases in which pharmacists and pharmaceutical companies are sued on the basis of product (drug) liability. These are often long and bitterly contested cases seen by the public as David against Goliath and all too often the toxicology of the drugs involved is the linchpin of the case. Lawyers are desperate for pharmacology-toxicology consultant help in these situations but until forensic toxicologists are able to grapple with mechanisms of clinical toxicity that can result from inappropriate drug use, and gain considerable new knowledge about toxicity which results from very long-term chronic use of drugs at non-toxic or therapeutic dosages, little enlightenment will be provided to the courts except in the most obvious cases.

The workplace is not excluded from the use of drugs, and it is also the place where occupational toxicities occur. If these lead to serious medical problems, disability or even death, then the forensic toxicologist can almost be assured of a part in the subsequent legal proceedings which are certain to ensue. These matters have grown in recent years to the point where they consume a significant part of the civil court's activities. Often huge sums of money are involved by way of compensation, and the opinions of forensic toxicologists are, therefore, of critical concern to workman's

compensation boards, trade unions, insurance companies, employers and the victims or their relatives alike.

It has become abundantly clear that the toxicologist, in partnership with his pathologist, medical-examiner colleagues, plays an increasing role as an ombudsman of public health issues and that this new dimension to his professional responsibilities is of almost frightening proportions. The alarm which is rightly felt in the profession can only be assuaged and brought into perspective by increasing the knowledge base from which toxicological opinions are rendered. Just a few example areas of immediate need have been mentioned, but they are critical, they cannot be avoided and they must receive appropriate attention soon, otherwise the profession will withdraw from this responsibility and shirk those very issues which their training and expertise should have fitted them to understand.

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GLOSSARY

Chromatography

A process by which components of an organic mixture are separated, by partitioning them between a stationary phase and a mobile phase according to their physical chemistry characteristics, such as solubility, boiling point.

Concentration Nomenclature

Gram: One thousandth of a Kilogram. 28 Grams= 1 ounce.
Microgram per Milliliter: 10^{-6}gram, One millionth of a Gram per one thousandth of a Liter.
Nanogram per Milliliter: 10^{-9}gram, One billionth of a Gram.
Picogram per Milliliter: 10^{-12}gram, One thousandth of a Nanogram.

Control

A biological specimen to which has been added a known concentration of a drug or chemical which is then analyzed at the same time as unknown or case specimens to control the quality of the analysis.

Deuterium

An isotope of hydrogen.

Drug Names

Almost all drugs have at least three names: a) chemical name b) generic name; a shortened single-word handy form of the chemical name c) trade or proprietary names, usually several depending upon the number of manufacturers.

Gas Chromatography (GC;GLC)

Chromatographic separation in which the stationary phase is usually a high boiling liquid and the mobile phase is a gas. The liquid is supported in a column and the gas carrying the mixture to be analyzed is passed through it. The constituents of the mixture take varying and characteristic times to travel through the column.

Gas Chromatography Detectors (Not a Complete List)

The means by which separated components of a mixture are detected as they exit the GLC analytical column.

Flame Ionization: Compounds in the carrier gas are mixed with hydrogen and burned in air. Electrons formed in the flame cause a current to flow in an external circuit. The current is measured and recorded. Will respond to molecules which contain carbon.

Electron Capture: The gas carrying compounds of interest are irradiated by either a tritium or nickel-63 source. Compounds which capture electrons produced by this process cause a change in the detector standing current which can be measured and recorded. Will respond particularly to compounds containing chlorine, or fluorine atoms.

Nitrogen-Phosphorus: Consists of a heated rubidium bead which creates a plasma environment reactive to nitrogen and phosphorus atoms in the molecules of compounds in the carrier gas. Very sensitive and selective for drugs because most contain nitrogen.

High Pressure (Performance) Liquid Chromatography (HPLC)

Chromatographic separation in which the stationary phase is usually a column of microparticulate material and the mobile phase is a liquid containing the mixture to be separated, passed through the column at high pressures, e.g. 2000 psi. The constituents of the mixture take different but characteristic times to travel through the column.

Iatrogenic

Illness resulting from medical treatment, often as the result of multiple drug therapy.

Immunoassay (RIA, EMIT)

A very sensitive, direct analytical technique which depends upon a reaction between an antigen (drug or chemical) and antibody raised to the antigen. The reaction is usually detected by either a radio-active label (RIA)or an enzyme label (EMIT) in the system.

Internal Standard

A compound, as chemically similar as possible to the compound (drug) to be analyzed, added to the biological specimen in known amount before the analysis, in order to internally monitor the analysis and to provide a means to quantitate the compound analyzed.

Isotope (Stable)

An element which has the same atomic number as another but different atomic mass.
Radio-active: An isotope which transmutes into another element by emission of radio-activity.
Stable: An isotope that does not transmute into another element.

Mass	The quantity of matter which a body (atom or molecule) contains, proportional to but different from its weight. The character of matter which gives it inertia.
Mass Spectrometry	A qualitative and quantitative analytical technique in which molecules are fragmented by electron bombardment. The profile of the fragments arranged according to their mass is recorded as the mass spectrum and is unique and reproducible for each organic molecule.
Metabolite	The biotransformation of a drug or other chemical usually to a simpler compound to facilitate its inactivation and elimination from the body.
Narcotic	A drug which produces sleep, but usually associated with Heroin, Morphine and related drugs which are both sedative and analgesic, and can induce tolerance and dependence.
Opiate	A naturally occurring constituent of opium.
Organic Chemical Classification	Acid: A compound which forms acid salts, and can be extracted from acidified biological (aqueous) samples into organic solvents. Base: A compound which forms base salts and can be extracted from alkaline biological samples into organic solvents. Neutral: A compound which does not form salts and can be extracted from both acid and alkaline biological samples into organic solvents. Amphoteric: A compound which can form both acid and base salts and can only be extracted from biological samples into organic solvents at single, specific conditions of acidity or alkalinity.
Reference Standard	A solution in water or organic solvent of a substance at accurately known concentration, which is used to prepare analytical controls and/or calibrate analytical instruments.
Relative Retention Time/Volume	The retention time or volume of a compound relative to a standard compound of a known Rt or Rv.
Retention Time	The time required to carry a compound through a chromatographic column. Generally used in gas chromatography.

Retention Volume	The volume of liquid (mobile phase) required to carry a compound through a high pressure liquid chromatography column.
Selectivity	The degree to which an analytical technique or method is able to recognize common characteristics of chemical groups, or is able to separate particular chemical types from each other.
Sensitivity	The lower limit of detectability of an analytical method. Usually expressed as a concentration in the biological specimen analyzed, or as the minimum weight of substance detectable by an analytical instrument, e.g. a gas chromatograph.
Specificity	The degree to which an analytical technique or method is unique in its identification of a substance.
Thin-Layer Chromatography	A chromatographic separation process in which the stationary phase is usually silica gel and the mobile phase organic solvent. The silica gel is thinly layered on a glass or plastic plate and dried hard. The solvent travels up the plate carrying the components of a mixture characteristic distances thus separating them.
Xenobiotic	Any substance foreign to the body.

END