

Forensic Science

T. A. Brettell*

Forensic Science Bureau, New Jersey State Police, Box 7068, West Trenton, New Jersey 08628

K. Inman

California Department of Justice DNA Laboratory, 626 Bancroft Way, Berkeley, California 94710

N. Rudin†

1563 Solano Avenue #506, Berkeley, California 94707

R. Saferstein

Box 1334, Mount Laurel, New Jersey 08054

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It is the aim of this article to present a concise survey of articles appearing in publications that primarily appeal to forensic practitioners. To accomplish this objective, we have focused our attention on the following journals: *Journal of Forensic Sciences*, *Science & Justice*, *Forensic Science International*, *Journal of the Canadian Society of Forensic Science*, *Forensic Science Review*, *Analytical Toxicology*, *Electrophoresis*, and *BioTechniques*, as well as *Chemical Abstracts Selects: Forensic Chemistry*. Our survey encompasses the period from January 1999 through December 2000. Because of the normal delays in the abstraction of journal articles by Chemical Abstracts, some work covering this period

will inadvertently be omitted. Hopefully these references will be included in the next biennial review.

The format selected for this survey divides coverage into three distinct areas:

forensic DNA analysis, trace evidence, and drug and poisons. Within the scope of each of the areas, key articles have been selected to describe current forensic science practices in analytical chemistry and to outline relevant forensic science research interests. In accordance with the policy of the Managing Editor we have strived to keep this review limited to important articles and to keep our discussions concise and meaningful.

FORENSIC DNA ANALYSIS

It is significant that, as we compile this review, recent headlines inform us that the DNA sequence of the human genome has been published in the journal *Science*. The era of using protein and biochemical marker systems for personal identification is now but a distant memory, and the use of DNA analysis in crime investigation is now expected. Over the last two years, the literature has focused on the development and validation of short tandem repeat (STR) typing systems. Given the wholesale adoption of this system by the forensic DNA community, the dearth of substantive peer-reviewed publications is astounding. This can be attributed in part to the fact that the typing reagents are manufactured as commercial kits by two competing companies, Promega Corp. and Applied Biosystems (formerly PE Biosystems). It will remain to be seen how research and publication will progress over the coming years.

In contrast to commercial STR systems, a relatively large literature base has been amassed for two less frequently used systems, Y-STRs and mitochondrial DNA (mtDNA). The papers about Y-STRs focus on the development of haplotype typing systems and the accumulation of population data. While few laboratories have yet availed themselves of this marker system, no doubt because it has only recently become available in a commercial kit form, Y-STRs are proving a useful adjunct to autosomal STR typing. Despite its known limitations for forensic use, mtDNA typing continues to command the attention of researchers. Recent literature has focused on the accumulation

* E-mail address: www.forensicdna.com.

of population data and attempts to understand the generation and inheritance patterns of heteroplasmy.

Before any DNA analysis can be undertaken, the biological sample must be recognized and preserved and the DNA successfully extracted from it. In addition, the end application of biological identification systems, at least for forensic use, is the solution of crime. Several papers are listed that address these bookends of the actual DNA analysis process. Finally, progress in investigating new techniques that promise miniaturization, automation, and mobility continue. In particular, research into the use of time-of-flight mass spectrometry to separate and analyze length polymorphisms continues, and DNA microarray chips that analyze current STR loci have been developed. A number of publications in this arena are listed.

Detection, Preservation, and Extraction of Biological Material. A method of recovering DNA from human teeth by cryogenic grinding is presented (1). Extraction and preservation techniques for DNA testing of urine samples are discussed. The samples were typed using the PM+DQA1 system (2). The effects of various powders used to visualize fingerprints on the ability to obtain DNA results are explored (3). A modified extraction of DNA from paraffin-embedded tissue samples is presented (4). Five extraction methods of DNA from decomposed human tissue for use in STR typing have been evaluated (5). The use of QIAamp and QIAshredder systems for extracting DNA from envelope flaps and stamps is evaluated (6). The effect of seven different blood enhancement reagents on the efficacy of DNA typing using the Profiler Plus system was studied (7). The possibility of recovering typeable DNA from adhesive tape was studied (8). An alkaline lysis method for DNA extraction from forensic samples is evaluated (9). The effect of laundering on the detection of acid phosphatase and spermatozoa on cotton T-shirts has been studied (10). The effect of luminol on STR typing of bloodstains has been investigated (11). The use of fluorescein for presumptive detection of dilute bloodstains and subsequent STR typing of recovered DNA was investigated (12). Ultrasonication as a method for preparing DNA from hard tooth tissue is presented (13).

Minisatellite Variant Repeat Analysis (MVR). De novo mutations and allelic diversity at minisatellite locus D7S22 were investigated using MVR-PCR analysis (14). A method of detecting dried saliva stains swabbed from human skin using fluorescence spectroscopy is presented (15). MVR-PCR was used to distinguish minisatellite mutation from nonpaternity (16). The D1S7 locus (MS1) was mapped using fluorescence detection MVR-PCR products (17).

Short Tandem Repeats. The autosomal STR loci CSF1PO, TPOX, THO1, vWA, D16S539, D7S820, D13S317, D5S818, F13A01, FESFPS, F13B, and LPL were studied and eight of them chosen to be validated together and combined into a commercial STR multiplex system under the name PowerPlex. Population studies were also performed (18). Paternity values for two different nine-locus STR systems were compared (19). Two STR systems, second-generation multiplex (SGM) and PowerPlex 1, have been validated for paternity use (20). A segregation analysis of tetra- and pentanucleotide short tandem repeat polymorphisms commonly used in forensic DNA analysis was performed (21). The utility of STR loci beyond human identification is discussed (22). The Profiler Plus STR typing system has been successfully used

in ancient DNA profiling (23). A validation study of the PowerPlex 1.1 system, including STR loci CSF1PO, TPOX, THO1, vWA, D16S539, D7S820, D13S317, and D5S818, is presented (24). A validation study of the SGM Plus STR typing system is presented (25). U.S. Caucasian and African-American populations were typed using the Profiler Plus and CoFiler systems, and the data subjected to various statistical analyses to determine whether the multilocus genotypes could reliably be used to estimate profile frequencies in forensic casework (26). Loss of heterozygosity in cancerous tissue was detected in a STR locus commonly used for human DNA identification (27). The evolutionary dynamics of STR loci have been explored (28). The utility of conventional blood groups, DNA minisatellites, and STRs for paternity testing are compared (29). Data from collaborative exercises and proficiency testing of the Spanish and Portuguese Working Group of the International Society for Forensic Genetics using various DNA typing systems are presented (30).

Gender Identification. A validation study of the gender identification locus, amelogenin, using capillary electrophoresis was performed (31). Seven novel, male-specific microsatellite markers from the human Y chromosome are reported (32). The results of a collaborative study regarding the standardization of the Y-linked STR system DYS385 by the European DNA profile (EDNAP) group is presented (33). Y-chromosome-specific microsatellite mutation rates have been reexamined using a minisatellite, MSY1 (34). A five-locus Y-STR multiplex system including DYS19, DYS389 I and II, DYS390, and DYS393 was investigated (35). Alternative primers for the STR locus DY391 have been compared (36). The distribution of Y-STR haplotypes in European males has been studied (37). The homology between DYS393 and its X chromosome counterpart, DXYS267, has been investigated (38). A case in which a rare mutation in a primer binding site resulted in the failure to amplify the amelogenin Y homologue from a phenotypically normal male is reported (39). Characteristics and frequency of germline mutations at microsatellite loci from the human Y chromosome were studied by direct observation in father/son pairs (40). A correlation between surnames and Y chromosome STR haplotype was investigated (41).

Mitochondrial DNA Typing. A report of the EDNAP on the reproducibility of mtDNA analysis between laboratories is presented (42). A study of the mtDNA control region in the Japanese population was carried out (43). Population and maternal inheritance data were gathered for the human mtDNA control region in the West German population (44). The possibility of combining mtDNA amplification with cytochrome *b* for simultaneous species determination was investigated (45). A human mtDNA standard reference material for quality control in forensic identification, medical diagnosis, and mutation detection has been developed (46). Denaturing gradient-gel electrophoresis revealed a high frequency of heteroplasmy in the hypervariable region 1 of the human mtDNA control region (47). The DNA Commission of the International Society for Forensic Genetics presents guidelines for mitochondrial DNA typing (48). The detection and quantitation of a 4977-bp deletion in (mtDNA) that accumulates in postmitotic tissues with advancing age was studied (49). The possibility of differentiating mtDNA by means of HVIII in samples that cannot be distinguished by sequencing the HVI and HVII regions was investigated (50).

Interpretation of DNA Typing Results. The interpretation of STR profiles derived from suboptimal amounts of DNA is discussed (51). An application of subpopulation theory to the evaluation of DNA evidence is discussed (52). The calculation of conditional genotypic probabilities for STR loci is discussed (53).

New Techniques. Progress has been made in using an automated system combining atomic force microscopy with pattern recognition software to size DNA fragments (54). Laser desorption mass spectrometry was explored as an alternative to electrophoresis for high-throughput DNA analysis (55). SNPs are analyzed using primer extension and time-of-flight mass spectrometry (56). The analysis of STRs using active microarray hybridization on an electronically active DNA microchip is reported (57).

Reviews, Cases, and Miscellaneous. STRs and mtDNA and short tandem were used to identify victims of the 1998 Philippine Airlines disaster (58). DNA was successfully recovered from a contact lens and analyzed using PCR DNA typing (59). The fidelity of polymerase chain reaction on direct sequencing analysis of damaged forensic samples has been investigated (60). The potential for recovery of typeable DNA from a toothbrush was investigated (61). DNA recovered from blood-engorged mosquitoes was typed using PCR at three VNTR loci and three STR loci (62). DNA testing using the PM+DQA1 system and the Profiler Plus system was performed on a body exhumed after 27 years (63). A study that investigates the effect of DNA damage on DQA1 typing is presented (64). MtDNA sequence analysis was used for the identification of human remains (65). DNA typing of human remains found in damp environments was carried out using STRs and mtDNA analysis (66). DNA typing at the amelogenin locus was used to verify extraction and amplification of authentic DNA from ancient human remains (67). MtDNA analysis was used in various cases to type small samples (68).

Population Database Studies. A population study of the Basque country of northern Spain was carried out using the STR triplex CSF1PO, TPOX, and THO1 (69). A population study of Italian Caucasians was carried out using the Profiler Plus and CoFiler STR systems (70). A study of the Chinese population in Taiwan was carried out using the STR markers: D3S1358, vWA, FGA, THO1, TPOX, CSF1PO, D5S818, D13S317, and D7S820 (71). A study of the Austrian population was carried out using the Profiler Plus system (72). The populations of three aboriginal communities, the Mapuche, Tehuelche, and Wichi, and the metropolitan population of the city of Buenos Aires were analyzed using the minisatellite loci D1S7, D2S44, D4S139, D5S110, D8S358, D10S28, and D17S26, the Amp-FLP D1S80, the autosomal STRs, THO1, FABP, D6S366, CSF1PO, TPOX, F13A1, FES/FPS, vWA, MBPA/B, D16S539, D7S820, D13S317, and RENA4, and the sex chromosome STRs, HPRTB, DYS385, DYS389I, DYS389II, DYS19, DYS390, DYS391, DYS392, DYS393, and YCAII. (73). A study of the population of northern Poland was carried out using the Y chromosomal polymorphic loci DYS19, DYS390, and DYS393 (74). Population data have been amassed from the mtDNA regions HVI and HVII in eight population groups: African-Americans, Africans (Sierra Leone), U.S. caucasians, Austrians, French, Hispanics, Japanese, and Asian Americans (75). A study of the Arab population in Egypt was carried out using the Profiler Plus kit (76). A study of a Saudi Arabian population has been

carried out using the STR loci: F13A01, FESFPS, F13B, LPL, CSF1PO, TPOX, THO1, and vWA (77). Italian population data for two new STRs, D2S1338 and Penta E, have been obtained (78). A study of the Mexican population using D1S80, APO-B, VWA, THO1, CSF1PO, and HPRTB has been carried out (79). A study of Philippine and Thai populations living in Taiwan was carried out using the Profiler Plus system (80). A study of the Japanese population has been carried out using three STR systems, PowerPlex 1.1, PowerPlex 1.2, and Profiler (81). A study of the Omani population has been carried out using the PM+DQA1 and Profiler plus system (82). A study of the Spanish population has been carried out using the Profiler Plus system (83). A study of five ethnic groups in China was carried out using the STRs: THO1, vWA, LPL, F13B, and FES/FPS (84). A study of the Slovene population was carried out using the STR loci: D3S1358, vWA, and FGA (85). A study of the Porto population of north Portugal was carried out using the STR loci: D3S1358, D18S51, D19s253, and FGA (86). A study of the distribution of Y chromosome STR defined haplotypes in Iberia was carried out (87). A study of the Central European population using mtDNA was carried out (88). A study of haplotype frequencies using nine Y chromosomal STRs was carried out in a German and a Chinese population (89). A study of two Hungarian populations was carried out using the eight STR loci: D3S1358, FGA, D8S1179, D21S11, D18S51, D5S818, D13S317, and D7S820 (90). A study of the Asturias population of northern Spain was carried out using the STR loci: CSF1PO, F13A01, FES/FPS, and D12S391 (91).

TRACE EVIDENCE

Petroleum Products and Explosives. The effective use of solid-phase microextraction (SPME) has been found to be sensitive for the detection of flammable liquids on skin (92). The detection of water-soluble accelerants from fire debris has been studied by headspace GC and SPME (93). A proposed two-step method based on SPME has been applied to the analysis of volatile petroleum products (94). The application of SPME to the recovery of explosives and flammable residues have been reviewed (95). SPME has been found to be a sensitive method for the analysis of volatile residues (96). Mason jars have been found to exhibit no appreciable contamination that would interfere with typical fire debris analysis (97). Volatile components have been detected in clothing, shoes, household products, building materials, paper products, cardboard, and adhesives. These results point out the need for collection of comparison samples in a fire investigation (98). Mass chromatography is currently being adapted by many forensic laboratories as the preferred approach for interpreting GC/MS data from fire debris samples. Software approaches for minimizing interferences and for facilitating the identification of petroleum liquids when this approach is used have been described (99). Sample preparation methods for the detection of ignitable liquids in suspect arson cases have been reviewed (100).

SPME has been evaluated for the recovery of explosives residues (101). An interface for coupling SPME to high-performance liquid chromatography (HPLC) has been examined with respect to the analysis of explosives (102). The aqueous recovery from cotton swabs of organic explosives residue followed by SPME has been studied (103). The field recovery of explosive residues using SPME followed by chromatographic analysis has been studied (104). A preliminary study of the analysis of

explosives using packed-column supercritical fluid chromatography with atmospheric pressure chemical ionization mass spectrometric detection has been reported (105). The analysis of explosives using ion mobility spectrometry (IMS) has been reported (106). The properties of triacetone triperoxide (TATP) have been reported (107). The analysis of trace explosives on swab samples has been described (108).

Fingerprints. The design of ninhydrin analogues for the development of latent fingerprints has been explored computationally (109). Significant evidence can be obtained from surfaces that are exposed to different enhancement chemicals without hindering DNA typing procedures (110). The performance of ninhydrin with regard to the detection of fingerprints was slightly better than that of benzo[*f*]ninhydrin (111). Etching and blueing processes, as well as multimetal deposition, have been used to reveal fingermarks on cartridge cases (112). The development of a one-step fluorescent lipid reagent that involves europium chelates has been studied as a method to detect latent fingerprints (113). Vacuum metal deposition has been applied to the development of latent fingerprints (114). Eosin-blue dye has been used to detect latent fingerprints on a wide range of surfaces (115). Silver physical developers for the visualization of latent prints on paper have been reviewed (116). The ability of 1,2-indanedione and 5,6-dimethoxy-1,2-indanedione to detect latent prints on porous surfaces has been evaluated (117).

Miscellaneous. The analysis of primer residue emanating from lead-free ammunition has been studied (118). Differential pulse anodic stripping voltammetry has been used to analyze lead and antimony in gunshot residues (119). Automated scanning electron microscopy coupled with image analysis and X-ray microanalysis was used to characterize a variety of gunshot residue samples (120). Industrial tools have been shown to produce barium, lead, and antimony particles that may be mistaken for gunshot residue (121). The detection of organic additives found in smokeless powder has been studied by capillary electrophoresis (122). The detection of smokeless powder residue on pipe bombs by capillary electrophoresis has been explored (123). The analysis and comparison of bullet leads by inductively coupled plasma mass spectrometry has been studied for the purpose of determining the origin of lead bullets (124).

Secondary ion mass spectrometry has been used for the forensic characterization of paint and fingernail polish (125). TLC and IR has been used for the forensic characterization of pigments found in automotive paints (126, 127). Infrared spectroscopy have been applied to the characterization of organic pigments present in automotive top coats (128, 129). Pyrolysis-GC/MS along with Raman spectroscopy has been investigated for the forensic characterization of automobile paints (130, 131). UV absorbers in two-coat metallic and nonmetallic automotive paints have been characterized by UV-visible spectroscopy (132).

A new polyester fiber commonly referred to as PTT (or PTMT) will apparently be on the market soon. The identification characteristics are provided in this paper so the new fiber can be correctly identified by forensic and industrial microscopists (133). The characteristics of modacrylic fibers for forensic analysis has been reported and includes over 80 samples representing 15 trade names (134). Using a statistical analysis of IR dichroic ratio data and fiber morphology, 32 polyester fiber samples were classified

into individual fiber groups (135). IR dichroic ratio data of common fibers can be used to monitor textile fiber quality and to compare fiber evidence in forensic investigations (136). A survey on the evidential value of fiber evidence has been conducted (137, 138).

Float glass is a common type of evidence collected from crime scenes. The multielement capability and the sensitivity of ICP-AES and ICPMS were examined for their discriminating power relating to glass analysis (139). The measurement of refractive index and trace element analysis by ICPMS were applied to the forensic discrimination of bottle glass samples from different origins (140). The forensic significance of glass trace elemental analysis and refractive index measurements was examined for their discrimination power (141). The variation in the refractive index of control glass samples submitted from crime scenes was investigated (142). The robustness of the Bayesian approach to forensic glass analysis has been demonstrated (143).

The postmortem changes in hair have been examined (144). Hair dye components have been characterized by GC/MS (145). The IR analysis of pressure-sensitive adhesive tape has been reported (146). The use of SPME-GC in forensic analysis has been explored. SPME is shown to be an inexpensive, rapid, and sensitive method for the analysis of a variety of forensic specimens (147). Electrospray ionization and matrix-assisted laser desorption/ionization mass spectrometry have been used to examine spermicidal evidence in a sexual assault investigation (148). The forensic analysis of organic materials in soil by FTIR has been shown to be a valuable analytical technique in forensic investigations (149). A high-density aqueous salt solution for the preparation of density gradients is presented (150).

DRUGS AND POISONS

Ethanol and Volatiles. Measurement of low breath-alcohol concentrations with current-generation evidential breath-alcohol test analyzers has been studied (151). The analysis of breath alcohol with a multisensor array has been evaluated (152). The reliability of breath-alcohol analysis in subjects suffering from gastroesophageal reflux disease (GERD) has been investigated (153). An accurate and simple method was developed to determine the level of toluene in urine and blood quantitatively by using gas chromatography/mass spectrometry (GC/MS) with a headspace-solid-phase microextraction (HS-SPME) technique (154).

Cannabinoids. A verification method using GC/flame ionization detection (GC/FID) for a Δ^9 -tetrahydrocannabinol (Δ^9 -THC) standard has been reported (155). Potency trends of Δ^9 -THC and other cannabinoids in confiscated marijuana from within the United States from 1980 to 1997 have been reported (156). An ELISA method has been described using ether extracts of marijuana samples to distinguish *Cannabis sativa* samples from different plant species (157). Δ^9 -THC and 11-nor-9-carboxy- Δ^9 -THC (THC-COOH) have been determined in whole blood by polar solid-phase extraction (SPE) and GC/MS (158, 159). THC-COOH has been detected in biological samples by GC/MS/MS (160) and liquid chromatography/MS/MS (LC/MS/MS) (161). THC-COOH has been determined in hair by mass-selective detection-negative chemical ionization (MSD-NCI) after HPLC cleanup (162).

Morphine and Related Narcotics. Noscapine was identified by GC/MS as an adulterant in 22 cases of illicit heroin (163). Street samples of heroin were analyzed by GC/FID to develop a predictive model for batching (164). A total of 198 illicit heroin samples were analyzed to determine the metal contents (165). The geographic origin of heroin and cocaine samples was determined using site-specific isotopic ratio deuterium nuclear magnetic resonance (166). The chemical profiling of illicit heroin samples has been reviewed (167). The postmortem redistribution of morphine and its metabolites was assessed in 40 heroin-related deaths (168). A method has been described for the analysis of etorphine in postmortem samples using HPLC with ultraviolet (UV) diode array detection (HPLC-DAD) (169). Heroin, cocaine, and ecstasy have been detected in hair by radioimmunoassay (RIA), HPLC, and capillary electrophoresis (CE) (170). Morphine has been identified in fingernail clippings by RIA and HPLC (171).

Cocaine. An ion trap GC/MS method for the determination of cocaine and metabolites and cocaethylene in postmortem whole blood has been validated (172). Benzoylcegonine has been determined in urine by aqueous-phase hexylchloroformate derivatization and SPE followed by GC/quadrupole ion trap mass spectrometry (173).

Amphetamines. Amphetamines have been analyzed by HPLC after acetylation (174), thermal desorption ion mobility spectrometry (175), and supercritical fluid chromatography (SFC), HPLC, and capillary zone electrophoresis (CZE) (176). 3,4-Methylenedioxy-*N*-methylamphetamine (MDMA) has been analyzed by ¹³C solid-state nuclear magnetic resonance (NMR) spectroscopy (177) and near-infrared spectroscopy (NIR) (178, 179). Profiling of impurities in illicit amphetamines has been accomplished by HPLC and CE (180), SPME (181), and SPE (182). The UV, IR, and NMR spectral properties as well as the chromatography and MS data have been reported for 4-methylthioamphetamine (183). Synthesis of 2,3- and 3,4-methylenedioxyphenylalkylamines and their regioisomeric differentiation by mass spectral analysis using GC/MS/MS has been reported (184).

Amphetamines have been determined in urine by automated in-tube SPME coupled with LC/electrospray ionization mass spectrometry (EIMS) (185). Amphetamines have been determined in blood by GC/MS after HS-SPME and derivatization (186). The achiral and chiral quantification of methamphetamine and amphetamine in urine has been done by semimicrocolumn HPLC with fluorescence detection (187). Amphetamines have been determined in hair by GC/MS (188) and supercritical fluid extraction (SFE) (189).

Benzodiazepines. Benzodiazepines were identified in biological fluids using dual-column GC and EMIT immunoassay (190), SPE followed by GC/MS (191), and automated in-tube SPME with LC/ESIMS (192). Alprazolam and its metabolites were quantitated in human plasma using LC/ESIMS/MS (193). Simple and rapid color screening tests for flunitrazepam have been reported (194). Data on confirmed flunitrazepam samples collected from DUI cases have been presented (195). Flunitrazepam has been identified in biological fluids using GC/MS (196, 197), SPE and GC/MS (198), immunoassay (199), and microplate enzyme immunoassay and negative chemical ionization (NCI) GC/MS (200).

Lysergic Acid Diethylamide (LSD). An overview of the drug action and detection of LSD has been reported (201). LSD has

been determined in urine using SPE and GC/MS/MS (202), HPLC-isotope dilution MS (IDMS) (203), and GC-ion trap MS/MS (204). LSD has been identified in blood and biological fluids using LC/ESIMS (205), HPLC with fluorescence detection (206), ELISA (207), and MS methods (208). LSD has been analyzed in body fluids and hair using immunoaffinity extraction and HPLC with fluorescence detection (209).

γ -Hydroxybutyrate (GHB). A new microcrystal test for the detection of GHB has been described (210). GHB has been analyzed in biological fluids by HSGC/FID and GC/MS (211), SPE, liquid-liquid extraction, silyl derivatization and GC/MS (212), liquid-liquid extraction, di-TMS derivatization and GC/MS (213), liquid-liquid extraction, BSTFA and TCMS derivatization, and GC/MS (214). Elevated GHB levels have been reported in citrate-buffered blood (215). The prevalence of drugs, including GHB and flunitrazepam, used in cases of alleged sexual assault has been reported (216).

Miscellaneous Drugs and Poisons. The chromatographic and spectrometric discrimination of fentanyl and its 24 analogues has been discussed (217). Three nonradioactive microtiter plate enzyme immunoassays have been evaluated for the detection of fentanyl in serum (218). Psilocin was detected in body fluids using hydrolysis, REMEDI HS, and GC/MS after silylation with MSTFA (219). A new method has been developed for the rapid analysis of psilocybin and/or psilocin in fungus material using ion mobility spectrometry (220). Methanolic extracts of various mushrooms were analyzed for psilocin and psilocybin by TLC and GC/MS (221).

A method was developed for the preparation of carboxyhemoglobin standards, which were stable for more than four months with the preparation control remaining within acceptable limits during this time (222). An automated headspace GC/MS method has been developed for the routine analysis of carboxyhemoglobin in autopsy materials (223). Cyanide has been determined in biological fluids spectrophotometrically by addition of strong acid and specific reaction with hydroxycobalamin to give cyanocobalamin (224).

General Procedures. Drugs of abuse have been analyzed by flash GC (225), SFC (226), CE (227), near-IR micro-Raman spectroscopy (228), and filtered fiber-optic Raman probes (229). An IR spectral library containing 455 controlled and noncontrolled solid drug standards was generated using internal reflection spectroscopy (230). Normalization of residual ions after removal of the base peak in electron impact spectrometry has been proven to be reproducible under a variety of conditions and can be valuable for compound identification (231). Validation procedures of 12 chemical spot tests for the detection of drugs of abuse have been described (232). Sampling and analysis methods for the detection of drugs on money have been reviewed (233). The ability to thermally desorb directly particulate matter, trapped on filter meshes, into the atmospheric pressure chemical ionization source of a tandem mass spectrometer allowed the simultaneous detection of a range of controlled substances within complex matrixes with a high degree of confidence (234).

The application of mass-selective detectors to the identification of the general unknown in forensic toxicology has been discussed (235). The use of SPME in forensic toxicology has been reviewed (236). The chromatographic screening techniques in systematic

toxicological analysis have been reviewed (237). The possibility of identifying the intake of subtoxic doses of four anxiolytic and/or sedative drugs has been investigated during the screening procedures for drug detection in biological fluids (238). GC with dual mass spectrometric and nitrogen–phosphorus-specific detection has been suggested for screening of basic drugs in human blood (239). A broad-scale TLC and RPTLC screening procedure for acidic, basic, amphoteric, and quaternary drugs, including ion-pair extraction of hydrophilic cationic drugs, has been applied to urine and liver samples from 618 medical examiner's cases (240). The analysis of drugs of abuse in hair has been accomplished by automated SPE, GC/EI/MS, GC ion trap/CIMS (241), tandem MS (242), and immunological methods (243).

Thomas A. Brettell is Chief Forensic Scientist of the New Jersey State Police Forensic Science Bureau. He received his B.A. degree (1973) in chemistry from Drew University, Madison, NJ; a M.S. degree (1975) in chemistry from Lehigh University, Bethlehem, PA; and Ph.D. degree (1987) in analytical chemistry from Villanova University, Villanova, PA. Dr. Brettell joined the New Jersey State Police Forensic Science Bureau in 1976. He was awarded The Chromatography Forum of the Delaware Valley Award in 1997. Dr. Brettell presently teaches forensic science in the Law and Justice Departments of The College of New Jersey and Rider University. From 1984 to 1998 he was a member of the faculty of the New Jersey Governor's School in the Sciences. He is a past-president of the Chromatography Forum of the Delaware Valley and has served on the A-Page Advisory Board of Analytical Chemistry. Dr. Brettell is on the Board of Governors of the Eastern Analytical Symposium, a Fellow in the American Academy of Forensic Scientists, and a certified Diplomate of the American Board of Criminalistics. He also holds memberships in the American Chemical Society, the New Jersey Association of Forensic Scientists, and the Northeastern Association of Forensic Scientists. His present research interests include headspace analysis in gas chromatography and Raman microspectroscopy.

Keith Inman is currently employed as a senior criminalist by the California Department of Justice DNA Laboratory. Mr. Inman holds a B.S. and M. Crim., both from the University of California at Berkeley. In his professional career he has been employed as a criminalist by the Orange County Sheriff's Department, the Los Angeles County Sheriff's Department, the Los Angeles County Chief Medical Examiner-Coroner, and the Oakland Police Department. He was in private practice for six years at Forensic Science Services of CA Inc., a private crime laboratory. Mr. Inman has coauthored *An Introduction to Forensic Analysis*, a book that has become the preeminent reference for both attorneys and crime laboratories. He teaches a variety of general forensic and forensic DNA courses for the University of California at Berkeley extension, on-line for Knowledge Solutions, and a criminal investigation course for California State University at Hayward. Mr. Inman is a member of California Association of Criminalists and a Fellow of the American Board of Criminalistics.

Norah Rudin is a private forensic DNA consultant, author, and educator. She was previously a DNA research consultant with the California Department of Justice DNA Laboratory and is currently Acting Technical Leader for the Idaho State Department of Law Enforcement DNA Laboratory. She is coauthor of *An Introduction to Forensic DNA Analysis* (CRC Press: Boca Raton, FL, 1997) and author of *Dictionary of Modern Biology*, Barron's: Hauppauge, NY, 1997. Dr. Rudin earned a Bachelor of Arts in zoology at Pomona College in Claremont, CA, and received her Ph.D. from the Department of Biology at Brandeis University with a concentration in molecular biology and genetics. She is an instructor for the University of California at Berkeley Extension, teaching both forensic DNA and general forensic science courses. She is also developer and instructor of on-line forensic DNA and forensic science courses with Knowledge Solutions. She is a published author of numerous general and academic articles. Her work has appeared in *Genetics*, *Molecular and Cell Biology*, *San Francisco Daily Journal*, *CAC News*, *Jurimetrics*, *TIE-LINE*, and other professional journals. Dr. Rudin lectures and has presented abstracts and scientific papers on genetics and forensic DNA analysis throughout the United States and internationally. Dr. Rudin is a provisional member of California Association of Criminalists.

Richard Saferstein is a forensic science consultant. He retired as Chief Forensic Scientist of the New Jersey State Police Laboratory in 1991. He received B.S. and M.A. degrees from the City College of New York in 1963 and 1966, respectively. He received his Ph.D. degree in chemistry from the City University of New York in 1970. Prior to his coming to the New Jersey State Police in 1970, he was employed as a forensic chemist with the Treasury Department (1964–1968) and served as an analytical chemist with Shell Chemical Co. (1969–1970). Dr. Saferstein is the author of a number of technical papers covering a variety of forensic topics. He has also written a book (seven editions) on the subject titled *Criminalistics: An Introduction to Forensic Science* (Prentice-Hall: Upper Saddle River, NJ, 2001) and has edited *Forensic Science Handbook, Volumes I–III* (Prentice-Hall: Upper Saddle River, NJ, 1982, 1988, 1993) and *More Chemistry and Crime* (Oxford University Press: New York, 1997) reference texts dealing with important forensic science topics. Dr. Saferstein has served on the editorial boards of the *Journal of Forensic Sciences*, *Journal of Applied and Analytical Pyrolysis*, and *Microchemical Journal*. He is a member of the American Chemical Society, the American Academy of Forensic Science, the American Microchemical Society, The Forensic Science Society, the Society of Forensic Toxicologists, the Canadian Society of Forensic Scientists, the Northeastern Association of Forensic Scientists, the Northwestern Association of Forensic Scientists, and the Mid-Atlantic Association of Forensic Scientists.

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