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Forensic Science

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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*, *Journal of the Forensic Science Society*, *Forensic Science International*, *Journal of the Canadian Society of Forensic Science*, *Journal of Forensic Identification*, *Forensic Science Review*, *Analytical Toxicology*, and *The Microscope*, as well as *Chemical Abstracts Selects: Forensic Chemistry*. Our survey encompasses the period from Jan 1989 through Dec 1990. 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: drugs and poisons, forensic biochemistry, and trace evidence. Within the scope of each of the areas, articles have been selected to describe current forensic science practices in analytical chemistry and to outline relevant forensic science research interests. To keep our discussion concise and meaningful, we have limited our survey to drugs regulated under the United States Controlled Substances Act, ethanol, and common poisons. Furthermore, to eliminate unnecessary duplication of effort, citations of articles appearing in *Clinical Chemistry*, *Journal of Pharmaceutical Sciences*, and other pharmaceutical journals have been minimized. We believe that ample coverage of these journals is provided within the pharmaceutical and clinical chemistry reviews planned for this journal. It is recommended that interested readers consult these sections in order to obtain a complete survey of the drug-abuse subject.

DRUGS AND POISONS

Ethanol and Volatiles. A critical analysis on the reliability of the Breathalyzer has been reported centering on the key chemical issues that are central to the controversy surrounding this classic breath-alcohol tester (*1*). The influence of temperature in breath-alcohol analysis has been evaluated (*2*). Hyperthermia was shown to effect the breath-alcohol decay curve, resulting in further support to previous recommendations that temperature monitoring be included in procedures for breath-alcohol analysis (*3*). Methanol could not be distinguished from ethanol with three breath-test instruments: Alcotest 7310 (a semiconductor sensing instrument), Alcolmeter SM-1 (an electrochemical fuel cell), and IR Intoximeter 3000 (an infrared absorptiometer) (*4*). The precision of breath-alcohol tests was evaluated by comparing in vitro measurements with in vivo measurements with the BAC Verifier Datamaster (*5*). The application of a variety of mathematical procedures to breath-alcohol profiles has been discussed (*6*). A report has described a data acquisition system that samples breath-alcohol concentrations at discrete intervals during exhalation (*7*). A study compared the accuracy, precision, and reliability of actual driving-while-intoxicated (DWI) IR Intoximeter 3000 breath-alcohol evidence gathered by field law enforcement personnel with the GC results of the magnesium perchlorate tube (MPT) alcohol analysis (*8*). Delayed ethanol analysis was performed on breath specimens collected over a 5-year period with commercial silica gel tubes by using multiple Breathalyzer instruments (*9*).

Intoxilyzer 5000 and direct injection internal standard blood-alcohol results from drivers arrested for operating a motor vehicle while intoxicated and for related offenses were compared during a 2-year period in Wisconsin (*10*). Analysis of data shows that 77% of the subjects breath-alcohol measurements actually underestimate their blood alcohol concentration while 23% were actually overestimated when the subjects were in the fully postabsorptive state (*11*). Breath-alcohol analysis has been compared to blood-alcohol analysis in order to estimate its reliability and explore the numerous consequences resulting from the use of these methods (*12*). An application of probability theory to a group of breath-alcohol and blood-alcohol data has been reported (*13*).

Results demonstrated that physiologic breath concentrations of acetaldehyde will not significantly affect the results of a breath-alcohol test when an Intoxilyzer 4011S-A is used for the analysis (*14*). No significant influence on measured ethanol values was found in tests with endogenous breath acetone using various U.S. Department of Transportation approved ethanol breath-testing devices of the IR type and one based on a wet chemical procedure) (*15*). The influence of everyday substances on Alcomat breath-alcohol measurements (mouthwashes, perfumes, aftershaves, etc.) has been reported (*16*). The response of the Intoxilyzer 4011AS-A to a number of possible interering substances has been studied and showed that the Intoxilyzer 4011AS-A was found to be an effective way of determining the ethanol concentration in human breath for evidential purposes despite 3 of 11 chemicals tested for their response to the 4011AS-A interfered only under unusual circumstances (*17*). The effect of respiratory aerosol inhalers and nasal sprays on the breath-alcohol testing devices used in Great Britain has been studied (*18*).

A study of the stability of ethanol in stored forensic blood samples showed that all samples studied exhibited a decline in ethanol concentrations over an extended period of time (*19*).

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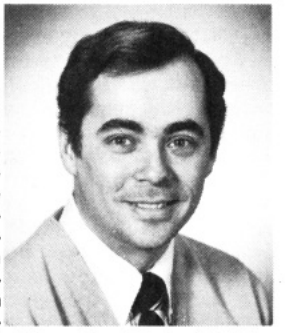

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Venous blood samples drawn from 14 drinking subjects were analyzed by a GC procedure and compared with serum samples analyzed by an automated alcohol dehydrogenase based enzymatic assay using a Du Pont ACA III Discrete Clinical Analyzer (*20*). A study of 75 autopsied persons from whom blood and subdural ethanol levels were obtained showed the usefulness of the subdural ethanol level, especially where there is a prolonged or unknown posttraumatic time interval (*21*). Ethanol concentrations in human blood samples were determined and compared by the Abbott TDx ethanol assay, GC, and chemical assays (*22*). Data given demonstrate that a valid determination of ethyl alcohol content can be performed on a clotted blood sample by headspace GC (*23*). The relationship between blood and urine alcohol concentrations at autopsy has been studied (*24*).

A simple, rapid ethanol screen based on a microdiffusion technique was found to be a viable screening test for the presence of ethanol in whole blood and urine and showed good agreement with a direct injection GC technique (*25*). A method for detection of ethanol in human blood and urine based on reaction of ethanol with CrO_3 in the presence of acid to produce a blue color was compared with an enzymic method for ethanol and shown to be a valuable prescreening tool for human blood and urine specimens (*26*). The disappearance rate of alcohol was studied from the blood of drunk drivers calculated from two consecutive samples (*27*). A paper described the analysis of ethanol in blood specimens from suspect drunk drivers by headspace GC with an internal standard and the associated quality assurance procedures currently used in Sweden for legal purposes (*28*). The effect of temperature on microbial fermentation in blood was studied using specimens of human blood from a blood bank inoculated with *C. albicans*, an organism capable of causing fermentation (*29*). Blood-alcohol concentration was determined by GC and ADH methods in 1672 (blood samples taken from) victims of sudden and unexpected natural and nonnatural out-of-hospital deaths (*30*). The frequency of alcohol intoxication was determined in victims of deliberate emergency wards covering a provincial/rural area and two metropolitan areas (*31*). A comparative study of ethanol concentration was performed in body fluids of human cadavers (*32*), and postmortem ethanol concentrations were determined in multiple sites from 307 autopsies (*33*). A report concluded that vitreous humor can be used to facilitate understanding the significance of postmortem blood-ethanol concentrations (*34*). Ethanol concentrations were determined in blood and paranasal sinus fluid of drowned humans (*35*). The importance of interaction of exhaled air with the airway surface was evaluated by comparing the effects of different breathing maneuvers and inhaled air temperature on the relationship between breath-alcohol concentration and blood-alcohol concentration (*36*). Studies of the blood clearance of ethanol in men of age $\leq$ 60 years following the oral consumption of 0.68 g/kg (as either hard liquor or wine) indicated no appreciable differences in peak blood concentrations, the time course of the blood-alcohol curve, or values calculated therefrom to values reported in the literature for younger subjects (*37*). The forensic significance has been discussed of the difference between the amount of ethanol actually consumed and the amount of consumed ethanol from blood-ethanol concentrations (*38*). The physiological variations in blood-ethanol measurements during the postabsorptive state were studied by headspace GC on samples of venous whole blood and arterial plasma (*39*). The mean blood alcohol (BAC) in 175 fatal cases of acute alcohol intoxication was found to be 355 mg/100 mL (*40*).

The stability of the alcohol concentration in urine specimens has been studied (*41*). An analytical–toxicological study of drinking drivers in Sweden who consumed denatured alcohol preparations was conducted (*42*). A modified headspace GC method for analysis of formate in biological fluids of victims of methanol poisoning has been described (*43*). Previously obtained blood-alcohol data were reevaluated to determine the extent of endogenous methanol, 2-propanol and 1-propanol formation in humans following the consumption of ethanol (*44*). Toxicology analyses and other forensic science data were used to examine the mechanisms through which ethanol increased the risk for death caused by injected street preparations of heroin (*45*). Instant and reliable semiquantitative information on the presence of alcohol in vitreous humor and urine samples in autopsy cases and in saliva from drunken drivers can be obtained by using the alcoscan test strip (*46*). The Office of the Medical Investigator for the State of New Mexico has assembled several cases of fatal alcohol intoxication in which the beverage source was a product that contained a high percentage of ethanol yet was clearly not intended for ingestion (*47*). A case is presented of a fatal drug interaction caused by accidental ingestion of methocarbamol and ethanol where biological fluids were screened for ethanol by using the Abbott TDx system and quantified by GLC and methocarbamol concentrations were determined in biological tissues and fluids by the colorimetric analysis of diazotized methocarbamol (*48*).

A study has been conducted on the effects of heat on blood and on the postmortem estimation of carboxyhemoglobin and methemoglobin (*49*). A fast and sensitive method for the determination of carboxyhemoglobin in blood using second derivative spectroscopy has been described (*50*). A review with five references has been published on carbon monoxide poisoning with emphasis on suicide involving carbon monoxide (*51*). In one study, it was found that potentially toxic concentrations of cyanide can develop in personnel involved in postmortem examination of cyanide victims (*52*). The effect of storage upon cyanide in blood samples has been studied (*53*). A colorimetric method for the screening of cyanide in biological specimens has been presented (*54*). A headspace method for the determination of blood cyanide by GC with electron-capture detection was developed by using a reaction precolumn (*55*). The differences in the levels of carboxyhemoglobin, hydrogen cyanide, and petroleum fuels (gasoline and kerosene) between left and right ventricular bloods from fire victims have been investigated (*56*). A newly developed reagent was evaluated for the determination of total hemo-

globin (Hb) in blood containing elevated carboxyhemoglobin (57).

Cyanide, carboxyhemoglobin, and blood acid–base state in animals exposed to combustion products of various combinations of acrylic fiber and gauze were used to examine the usefulness of blood cyanide concentrations as an indicator of whether or not a victim was alive at the start of a fire (58). Blood from 75 of the victims from the Du Pont Plaza Hotel fire in Puerto Rico was analyzed for carboxyhemoglobin with a CO-Oximeter and for cyanide by headspace GC (59). Current derivative spectrophotometric methodology for the determination of percent carboxyhemoglobin saturation in postmortem blood samples has been evaluated (60). A fetal death due to accidental nonlethal maternal carbon monoxide intoxication in which both maternal and fetal carboxyhemoglobin concentrations were obtained by using the FL 282-CO-Oximeter has been reported (61). A prospective study of the role of hydrogen cyanide and carbon monoxide in fire casualties has been reported (62). Levels of cyanide in postmortem specimens from a victim of suicide by inhalation of hydrogen cyanide were obtained by microdiffusion and UV spectrophotometry (63).

An introduction to the practice, prevalence, and chemical toxicology of volatile substance abuse has been reported (64). The medicolegal importance of volatile substance abuse, as an example of toxicological deaths, has been reviewed (65). Components of paint thinner in body fluids have been detected by using a salting out technique with headspace sampling and GC (66). A newly designed apparatus for testing blood levels of fuel vapor from a suicide victim has been described (67). The correlation between "on admission" blood-toluene concentrations and the presence of absence of signs and symptoms in solvent abusers has been done by using GC (68). The course of respiration and circulation in "toluene sniffing" has been discussed (69). The presence of toluene in body fluids and tissues has been detected by GC and GC/MS (70) and in blood by headspace GC (71).

A simple and rapid method for analysis of free and conjugated cresols in biological fluids has been developed which uses acid hydrolysis, GC, and GC/MS (72). Concentrations of phenol were determined in blood, urine, and other tissues of an accidental death from injection by GC-FID and GC/MS (73). A simple procedure for the determination of ethylene glycol in blood by capillary GC has been developed (74). Cyclopropane was determined by headspace GC and GC/MS in blood and lung from an overdose victim (75). Headspace GC has been used to detect and quantify enflurane in blood and other biological fluids from victims of enflurane intoxication (76, 77). Trichlorotrifluoroethane was determined by GC in blood, urine, and tissues from a victim who died as a result of exposure (78). The body distribution of ethychlorvynol from two fatal cases of ethychlorvynol overdose was reported from toxicological analyses of body fluids and tissues using GC-FID (79). Cases of ethychlorvynol injections over a 14-year period from San Diego County were reviewed in order to evaluate the current status of ingestion of this drug (80).

Cannabinoids. An improved and alternative TLC method has been developed for the detection and identification of Cannabis involving prechromatographic derivatization of the cannabinoids present in Cannabis (81). Distinctive aging processes due to the physical and chemical pecularities of samples of different geographic origin have been observed by GC-FID (82). A simple method for the estimation of Δ9-THC in cannabis has been reported involving the oxidative coupling of cannabinoids in cannabis with 3-methylbenzothiazolinone 2-hydrazone (83). The conformational analysis of Δ9-THC and Δ9,11-THC in solution has been performed by using high resolution nuclear magnetic resonance spectroscopy (84).

The results of a round robin test are given from among five Department of Defense laboratories on SRM 1507, a freeze-dried urine fortified with 11-nor-Δ9-THC-9-COOH, the major urinary metabolite of marijuana, prepared and certified by the National Institute of Standards and Technology (NIST) (85). Determination of Δ9-THC metabolites in urine has been performed by using TLC (86) and GC/MS (87–89) and in urine and plasma by HPLC with electrochemical detection (90). 11-Nor-Δ9-THC-9-COOH was determined from human urine by selective sample preparation and GC-EC (91) and by solid-phase extraction and GC/MS (92, 93) and GC/MS, HPLC with UV detection, and GC-FID (94).

Five commercially available immunoassay techniques were compared for the determination of cannabinoid metabolites in urine at a positive cutoff of 100 μg/L (95). Various immunological methods have been compared with GC/MS analysis in the detection of cannabinoids in urine (96–98). A TLC method has been compared with EMIT and GC/MS for the detection of cannabinoids in urine (99). Cannabinoids have been detected in urine by using various immunoassays techniques such as EMIT (100), an enhanced chemiluminescent enzyme immunoassay (101), and the Abbott TDx urinary cannabinoids assay (102).

A review on the relationship of drug levels, marijuana in particular, to impairment of performance has been reported (103). Various studies have been performed on the false-negative and false-positive results on various immunoassay systems (104–109). A case has been presented that discusses that interpretation of urine quantitative 11-nor-Δ9-THC-9-COOH data to determine abstinence from marijuana smoking (110). Urinary excretion half-life of Δ1-THC-7-oic acid in marijuana users was determined by EMIT and HPLC (111) and by EMIT, HPLC, and radioactivity of ^{14}C (112).

A GC/MS method for the analysis of Δ1-THC in human fat samples has been described (113). The determination of Δ9-THC and its metabolites in blood has been accomplished by solid-phase extraction and HPLC with electrochemical detection (114, 115) and by GC/MS (116). Optimization of the EMIT immunoassay procedure for the analysis of cannabinoids in methanolic blood extracts has been described (117). A comprehensive epidemiological study of the involvement of cannabis and ethanol in motor vehicle fatalities in the Providence of Ontario, Canada, is described where the ethanol was determined in blood by headspace GC and the cannabis was detected in blood and urine by RIA and GC/MS (118).

Morphine and Related Narcotics. Heroin and three structurally related isomers were studied by using NMR, GC/MS, IR, and GC with packed and capillary columns (119). Based on the infrared spectrum of heroin base, there is strong evidence to support the view that at least two polymorphic forms of heroin base with various crystal habits exist, with the main parameters being the temperature conditions and solvent used for crystallization (120). A comparison of derivatives for the determination of codeine and morphine by GC/MS has been reported (121). The potentiometric response characteristics of a poly(vinyl chloride) membrane electrode for heroin based on its ion-pair complex with tetraphenyl borate were examined (122). A voltammetric assay of heroin in illicit dosage forms has been described that studied the oxidation of heroin on a carbon paste electrode (123). Adulterant drugs in heroin preparations from Southwest Asia known as Kerachi were identified by GC/MS (124). A split–splitless capillary inlet which is temperature programmable was used for quantification of illicit heroin samples by high resolution gas chromatography HRGC (125). A binary gradient reversed-phase liquid chromatographic system for the qualitative and quantitative estimation of morphine, codeine, thebaine, papaverine, and narcotine in gum opium samples has been described (126).

Solid-phase extraction and GC/MS were used for the determination of morphine, codeine, and 6-monoacetylmorphine in blood (127). A single step liquid–liquid extraction procedure followed by pentafluoropropionic anhydride derivatization was developed for the analysis of free morphine in blood by using MS/MS in the multiple reaction monitoring mode (128).

An overview of separation methods and detection techniques for the determination of morphine in biological samples using HPLC has been presented (129). Morphine and other related narcotics have been analyzed in biological fluids by using HPLC with electrochemical detection (130, 131), with UV detection (132), and with fluorescence detection (133, 134).

The detection of drugs of abuse in urine by four commercial immunoassay systems and one commercial TLC system was investigated, and results were compared with those obtained by a dual-column capillary GC system (135). The Abbott TDx analyzer was applied to the detection and quantification of total opiates in whole blood (136) and in liver, bile, and urine (137). A study has been reported that was designed to correlate the amount of poppy seeds ingested with the urinary concentration of total morphine as a function of time (138).

6-Monoacetylmorphine has been determined in urine as an indicator of heroin abuse by GC/MS (*139–142*) and by GC and dual NPD-FID detection (*143, 144*).

RIA and GC/MS have been used to determine morphine in human hair (*145, 146*). Morphine and phenobarbital were simultaneously identified by GLC and assayed by FPI in several tissues of a putrefied cadaver and in the fly larvae of *Calliphoridae* found on the corpse (*147*). Case data from 200 morphine-involved deaths analyzed for patterns and relationships using Artificial Intelligence (AI) computer software demonstrated that inexpensive AI programs commercially available for personal computers can be useful in interpretation in forensic toxicology (*148*).

Cocaine. Currency obtained from a bank were analyzed quantitatively for cocaine by using GC-NPD and GC/MS (*149*). A simple chemical test was used to determine whether a suspect specimen contains cocaine and if so whether it is present as free base cocaine or in a salt form based on the relative solubility of the two compounds in aqueous or organic solvent and the widely accepted cobalt thiocyanate color reaction (*150*). An assay of crack has been described based on the analysis of cocaine by GC/MS and on the discrimination between crack and cocaine by their different solubilities in water and diethyl oxide (*151*). An online multidimensional chromatographic system coupling HPLC and capillary SFC has been developed to analyze for trace impurities in illicit cocaine (*152*). An automated procedure has been described that uses a laboratory robotics system for the quantitative analysis of phencylidine and cocaine (*153*).

A facile procedure for the synthesis of pseudococaine from cocaine has been described (*154*) as well as the complete chromatographic resolution of cocaine and pseudococaine by HPLC (*155*). The pyrolysis and volatilization products of cocaine were studied by GC/MS (*156*). The use of thermoanalytical techniques has been suggested for the direct analysis of cocaine and cuts without any preliminary sample treatment, thus avoiding artifacts due to the sample pretreatment or to the analysis operative conditions (*157*). A rapid procedure based on second derivative UV spectrophotometry was used for the simultaneous determination of cocaine and other local anesthetics (*158–161*). Pseudoecgonine was detected and resolved from ecgonine in illicit cocaine samples by narrow bore capillary GC at levels of less than 0.1% (*162*).

An efficient and simple extraction method for cocaine in human urine has been developed (*163*). Variations in the abundance of the molecular ion of the derivatized cocaine metabolite, benzoylecgonine, have been studied (*164*). Empirical data have been used to demonstrate the observation and quantification of benzoylecgonine in negative test samples when high concentrations of deuterated benzoylecognine are used as the internal standard in the assay process (*165*).

The detection of benzoylecgonine and other cocaine metabolites in urine has been accomplished by solid-phase extraction and HPLC (*166*), HPLC with UV detection (*167*), EMIT (*168, 169*), EMIT and GC/MS (*170–172*), EMIT and GLC-NPD (*173*), EMIT and TLC (*174*), ELISA and GC/MS (*175*), and the Abbot TDx FPI (*176*).

The prolonged occurrence of cocaine in human saliva and urine after chronic use was monitored by immunoassay and GC/MS (*177*). Cocaine and 11 of its metabolites were identified in a urine specimen from a cocaine user using GC/EI and CIMS; four of the metabolites were reported for the first time (*178*). The cocaine pyrolysis product anhydroecgonine methyl ester (AEME) was determined in urine by GC/MS (*179*). HPLC has been used for the determination of cocaine and its metabolites concentrations in vitreous humor (*180*), in serum (*181*), in plasma (*182*), and in plasma and cell cultures (*183*). Comprehensive studies of the stability of cocaine and its metabolites in blood have also been reported (*184, 185*).

The disposition of radiolabeled cocaine in humans was studied after i.v. injection, nasal insufflation (ni, snorting), or smoke inhalation (si) (*186*). Benzoylecgonine was determined in human hair of cocaine abusers after hair hydrolysis, extraction by chloroform, derivatization by pentafluorobenzyl bromide, and GC/MS (*187*). A report concluded that dermal absorption of cocaine represents a minor but significant route of exposure to this drug that needs to be considered when interpreting low-level urine drug testing results (*188*). Cocaine and benzoylecgonine concentrations have been reported in body fluids analyzed by RIA and GC/MS on 25 cases of either fetal or newborn death associated with maternal cocaine use (*189*). Toxicologic screening for cocaine and its metabolites was performed on 103 cases of fetal death, and cocaine and its metabolites were found in 64 cases in the blood or brain (*190*).

A review of all autopsy and toxicology reports from NYC in an 11-month period found 935 deaths with cocaine (*191*). The toxicologic results of cocaine distribution studies performed on a pregnant woman and her fetus have been given (*192*). Cocaine and methamphetamine-related homicides and fatal accidental overdoses in San Diego County were studied retrospectively for the 1987 calendar year (*193*). The incidence of detection of cocaine or its metabolites (by EMIT and GC or GC/MS) in Wayne County (Michigan) Medical Examiner's cases from 1984 to 1987 was reported (*194*). An example of cocaine tolerance in a gunshot wound fatality has been described (*195*). Cocaine and benzoylecgonine were quantified in blood, liver, and amniotic fluid from six cocaine-related deaths (*196*). A comparison of the results obtained with the Abbott TDx immunofluorescence analyzer and those of GC/MS in a fetal case of pure cocaine injection has been reported (*197*). Cocaine, benzoylecgonine, and ecgonine methyl ester concentrations were determined in blood from a cocaine fatality by GC/MS (*198*).

Amphetamines. HPLC methods have been described for the analysis of forensic samples containing amphetamine and methamphetamine (*199*). A review has been published with 93 references on the synthetic reductions utilized in the clandestine manufacture of amphetamine and methamphetamine (*200*). GC/CIMS and GC/FT-IR were compared for three test mixtures of stimulants (*201*). Lithium/ammonia/ammonium chloride reduction of ephedrine has been found to be a viable synthesis for methamphetamine (*202*). The illicit manufacture of methamphetamine from ephedrine via reduction with hydriodic acid and red phosphorus has been discussed (*203*).

Amphetamine and related compounds have been detected in urine with various immunoassays such as PFI (*204*) and RIA (*205, 206*). An enzyme immunoassay and an ELISA method were developed with alkaline phosphatase as a label enzyme to detect methamphetamine in urine (*207*). A modified version of a commercially available RIA was investigated as a screen for methamphetamine in whole blood and urine (*208*). Underivatized amphetamine has been identified and quantified in human whole blood by GC-NPD (*209*) and in plasma and urine by GC-FID (*210*). Derivatization has also been used to identify and quantify amphetamine and methamphetamine in urine by solid-phase extraction and GC/MS or GC-NPD (*211*), liquid–liquid extraction and GC/MS (*212, 213*), and capillary GC-FID (*214*). Several racemic amphetamine-related compounds were derivatized with a chiral derivatizing reagent and detected with isothermal capillary GC-EC (*215*).

Headspace GC has been used to detect amphetamine and methamphetamine in urine by salting out the underivatized drugs (*216*) and using simultaneous derivatization (*217*). The diazonium reagent Fast Black K salt was evaluated for the visualization of amphetamine-like compounds on silica gel TLC plates (*218*). The automation of zone-electrophoretic sample treatment for HPLC has been described (*219*). Several HPLC methods have been described for the detection of amphetamine and methamphetamine in biological fluids such as solid-phase extraction and ion-pairing agents (*220*), HPLC and UV detection (*221*), HPLC and chemiluminescence detection (*222, 223*), and HPLC with chemiluminescence and fluorescence detection (*224*).

Two novel membrane electrodes have been developed and electrochemically evaluated which show high selectivity and display fast response for as low as 3 μg/mL of amphetamine (*225*). Methods have been described for the detection and quantification of methamphetamine in hair (*226*) and in hair, nails, sweat, and saliva from habitual users of methamphetamine (*227*). The tissue concentrations of methamphetamine and amphetamine, metabolites of Selegiline, were determined by GC/MS in the case of an apparent suicide by Selegiline (*228*). Tissue distribution of methamphetamine and amphetamine in premature infants from an amphetamine-abusing mother were reported (*229*). The pyrolysis products of smoking methamphetamine mixed with tobacco were de-

termined by GC and GC/MS (*230*). GC/MS was used to assess the toxicity of methamphetamine and amphetamine over a 2-year period from postmortem rabbit skeleton muscle and bone marrow (*231*).

Liquid chromatographic and mass spectral data have been given for methoxyamphetamines and methoxymethamphetamines (*232*), the N-substituted analogues of 4-methoxyamphetamine (*233*), N,N-disubstituted 3,4-methylenedioxyamphetamines (*234*), homologues of 3,4-methylenedioxyamphetamines (*235, 236*), and regioisomers of the 3,4-methylenedioxyamphetamines (*237*). Spectral and chromatographic data have also been presented for each of some 3,4-methylenedioxyphenylisopropylamine analogues (*238*). The potential precursors and candidates for the clandestine manufacture of 3,4-methylenedioxyamphetamine analogues and homologues were evaluated by using a variety of analytical techniques (*239*). A mass spectrometric study has been published of some reaction mixtures from the clandestine manufacture of 3,4-methylenedioxymethylamphetamine (MDMA) by low pressure reductive amination (*240*). MDMA as the pentafluorobenzoyl derivative was assayed by positive ion CIMS using ion trap detection's automatic reaction control scan function (*241*).

The liquid chromatographic data of regioisomers and enantiomers of *N*-(chlorobenzyl)-α-methylphenethylamines have been given (*242*). 2,5-Dimethoxy-4-ethoxyamphetamine was synthesized by two routes, and it and its precursors were studied using GLC, UV, IR, H^1 NMR, C^{13} NMR, and GC/MS (*243*).

The optical crystallographic or microcrystalline properties of the diliturate derivatives (5-nitrobarbituric acid) of the most used psychedelic amphetamine drugs have been determined (*244*). Two new designer amphetamines (4-chloro-2,5-dimethoxyamphetamine and 2,5-dimethoxy-4-methylthioamphetamine) were identified by NMR techniques (*245*). The chemical and physical properties of (*Z*)- and (*E*)-monoethoxy-1-(2-nitro-1-propenyl)benzenes, important precursors to monoethoxyamphetamines, have been given (*246*).

Analysis of a sample by FPI, GC, UV, and GC/MS showed the material originally sold as amphetamine to be *p*-methylamphetamine and *N*,*p*-dimethylamphetamine (*247*). MDA and MDMA enantiomers have been determined by whole blood by GC/MS (*248*). HPLC has been used to determine *N*-hydroxy-MDA and MDA in plasma (*249*). Amphetamine immunoassays were used to detect MDMA and MDEA in urine (*250*). Several metabolites of MDMA have been identified in the urine (*251*).

Barbiturates. The relative efficiencies of four enzyme digestion procedures and two conventional methods in releasing barbiturates from liver tissue were compared by using HPLC (*252*). A reversed-phase HPLC method has been described for the simultaneous identification and determination in human blood of five barbiturates (*253*). A simple and rapid method for isolation of nine barbiturates with Sep-Pak C18 cartridges from human urine, plasma, and whole blood is presented with detection by wide-bore capillary GC-FID (*254*). Confirmation and quantification of barbiturates in human urine have been accomplished by GC/MS (*255*). Methadone and phenobarbital have been determined in human hair by RIA (*256*). The capability of the Abbot ADx assays to test for PCP and barbiturates in urine specimens was evaluated by comparison to TDx, EMIT, and GC/MS methods (*257*).

Miscellaneous Drugs and Poisons. EIMS when combined with other analytical techniques (GLC, TLC, HPLC) has been shown to be capable of differentiating LSD from other *N*-methyl-*N*-propyl- and *n*-butylamides of lysergic acid (*258*). LSD has been determined in urine by GS/MS (*259, 260*), GC/NICIMS (*261*), and HPTLC (*262*). Serum and urine specimens of people suspected of LSD intoxication were analyzed for LSD by RIA and confirmed by HPLC (*263*). The evaluation of a commercial RIA kit for the detection of LSD in serum, whole blood, urine, and stomach contents showed good precision and recoveries of spiked samples (*264*).

A modified solvent extraction technique has been reported that can increase the recovery of fentanyl from urine (*265*). A GC/FT-IR spectrometric analysis of five monomethylated fentanyl related compounds widely abused designer drugs was evaluated, and spectra obtained were compared with those measured in the condensed phase (*266*). Immunoassay methods used to analyze fentanyl in urine were developed by using RIA (*267*) and ELISA (*268*) and comparing RIA methods with GC/MS (*269, 270*). Fentanyl has been determined in body fluids from fatal victims by using GC-NP (*271*) and GC/MS (*272*).

An extensive collection of mass spectra of benzodiazepines has been reported (*273*), and chemical ionization ion mobility spectrometry was used to characterize a number of benzodiazepines (*274*). Eleven benzodiazepines were separated by using supercritical fluid chromatography on columns packed with polystyrene–divinylbenzene and ODS- and cyano-bonded silica (*275*). Alogrithms based on the pattern of benzophenone derivatives of benzodiazepines obtained by GC/MS were used to confirm and identify benzodiazepines and their metabolites initially detected in urine by EMIT (*276*). Microcolumn cleanup and HPLC/ECD have been used to determine benzodiazepines in contaminated and degraded blood samples (*277*). The determination of lorazepam in blood by GC/MS with selected ion monitoring in the negative chemical ionization mode was investigated (*278*). A simple spectrophotometric determination of diazepam in illicit alcoholic liquors has been presented (*279*).

Phencyclidine (PCP) was identified and quantified in urine by combined GC/MS following solid-phase extraction (*280*). PCP extracted from urine was detected by GC/NPD with acetylated column packing material (*281*). A GC/MS procedure has been developed in which the 13 major components, including PCP and PCC, found in typical clandestine mixtures may be screened for and identified (*282*). Impurities found in the two principal methods of the manufacture of *N*-ethyl-1-phencyclohexylamine (cyclohexamine, PCE) were identified by using proton NMR, FT-IR, and capillary GC/MS (*283*).

A review of 323 fatal poisonings with dextropropoxyphene has been presented (*284*). The analyses of bone marrow and body tissue (adipocere) from a severely decomposed body for the presence of paracetamol and dextropropoxyphene have been described (*285*). A novel extraction procedure for psilocybin and psilocin determination in mushroom samples has been described (*286*). Psilocybin, psilocin, and other psychotropic indole derivatives have been determined by HPLC using electrochemical and UV photometric detection (*287*). A simple, rapid, and sensitive voltammetric method for the determination of methadone in human urine has been proposed (*288*). A simple continuous redox flow system coupled online with an atomic absorption spectrometer for the determination of methadone has been developed (*289*). The first and second derivative UV spectrophotometry was applied for the estimation of methaqualone (*290*). A variety of liquid–liquid and solid-phase techniques have been compared for the extraction of tricyclic antidepressant drugs from small whole blood samples (*291*). The use of the EMITtox serum tricyclic antidepressant assay for the analysis of urine samples has been proposed (*292*). An efficient method for solid-phase extraction of these drugs from vitreous humor and a reversed-phase, isocratic HPLC method has been prepared for the simultaneous quantification of amitriptyline, doxepin, and imipramine and their desmethylated metabolites (*293*).

Physical constants and instrumental data have been reported for the individual stereoisomers of 4-methylaminorex (*294*), and the spectral distinction between *cis*- and *trans*-4-methylaminorex has been reported (*295*). Methylphenidate in plasma has been determined by GC/MS (*296*). A GC/MS method for the rapid quantification of atropine in blood has been presented (*297*). A case has been presented of a death caused by self-injection of sufentanil and midazolam where the biological fluids were analyzed for midazolam by HPLC and GC/MS and for sufentanil by GC/MS (*298*). A review reports on case studies of the abuse of midazolam and the consequences for forensic and traffic medicine (*299*). A sensitive RIA for paraquat has been reported which allows determination of paraquat in tissues of paraquat-poisoned cadavers (*300*). The determination of meprobamate in serum has been accomplished by alkaline hydrolysis, trimethylsilyl derivatization, and detection by GC/MS (*301*). A rapid HPLC method with UV detection for the determination of tocainide in plasma, using *N*-(2,6-dimethylphenyl)-2-amino-butaimide as an internal standard, has been developed (*302*). The comparison of absorbance ratios and peak purity parameters for the discrimination of promazine and promethazine has been accomplished by using HPLC with multiwavelength

detection (*303*). A study on the spectrophotometric determination of pentazocine by its oxidative coupling with 3-methylbenzothiazolinone 2-hydrazone has been reported (*304*).

A method has been described for the rapid HPLC analysis of a number of anticonvulsant drugs in vitreous humor by injection directly onto a preconcentration column without the need for prior extraction (*305*). A comparison was given of chemical methods for determining postmortem interval (*306*) and the estimation of postmortem interval by using kinetic analysis of the third component of complement (C3) cleavage (*307*).

Urea and potassium ion concentrations in vitreous humor were correlated for reference to the determination of time of death (*308*). Isotachophoresis was successfully used to determine the lactate ion concentrations in 40 vitreous humor samples (*309*). A simple and rapid method for isolation of 11 organophosphate pesticides with Sep-Pak C18 cartridges from human urine and plasma has been presented that seems very useful for autopsy specimens (*310*). Malathion content was measured by using GC-NPD following solvent extraction from larvae of decomposing remains from a suspected case of organophosphate poisoning (*311*). An HPLC method for the determination of diuron and its metabolites in human urine and blood has been presented (*312*). Positive-ion electron impact, positive-ion chemical ionization, and negative-ion chemical ionization mass spectra of nine carbamate pesticides have been presented from common carbamate poisoning autopsy samples (*313*). The estimation of the body burden of arsenic in a child fatally poisoned by arsenite weedkiller has been reported (*314*). A simple, sensitive, and rapid quantitative method for Dipterex in serum has been described that used a SepPak C18 cartridge for the extraction and GC with flame thermionic detection for determination in poisoning cases (*315*). The experience of 1 year's proficiency testing on drugs of abuse in Spain has been discussed (*316*). A comparison of drug abuse data in different military populations has been reported (*317*) as well as several surveys of drugs in driving under the influence cases (*318–321*).

The characterization of xylometazoline and its imidazole metabolite by mass spectrometry from an extract of human postmortem liver has been described (*322*). Sixteen fatalities occurring in Ontario from suicidal ingestion of diphenhydramine were reviewed (*323*). A case of possible malicious poisoning of dogs by endrin was investigated by quantifying endrin in a variety of tissues by GC/MS (*324*). Three case histories of deaths involving triazolam and the analytical procedures used for the identification and quantification of triazolam in blood have been described (*325*). A case of suicidal ingestion of sodium fluoride roach powder has been presented (*326*). The determination of diquat when paraquat is also contained in the solution can be accomplished by extraction with 1-butanol from high pH solution (*327*). An unusual case of fatal accidental paraquat poisoning has been described (*328*). A new colorimetric method has been described for the quantification of diquat based on the reduction of diquat with either 2-mercaptoethanol, DL-dithiothreitol, or L-cysteine in 0.2 M NaOH (*329*).

Methomyl was detected in the biological fluids of victims from a fatal and nonfatal attempted double suicide by GC/MS (*330*). Fenitrothion and its metabolites in the body fluids of a poisoning victim were extracted by an Extrelut column extraction method, detected by GC-FID or GC-FPD and confirmed by GC/MS (*331*). GC-FID and GC-ATD were used to detect and quantify Remoxipride from a suicide victim (*332*). GC-FID was used to quantify carbofuran in the liver, brain, and kidney of the fetus of a pregnant woman who was the fatal victim of carbamate pesticide poisoning (*333*). HPLC was used to detect and quantify sodium azide in the urine of an accidental poisoning victim (*334*). Thiamyl was quantified in blood and other body fluids from a suicide victim by HPLC with UV detection and was confirmed by GC/MS (*335*). Serum analysis by capillary GC/MS confirmed the presence of dextromoramide in a man found in his car suffering from a heart attack (*336*). Sulfide concentrations in postmortem mammalian tissues were correlated with time of death (*337*). Second derivative UV–visible spectra were used to detect and study the release of paraquat into the formalin solution used during fixation (*338*). Causes of death in hospitalized intravenous drug abusers have been reviewed (*339*). Data regarding tissue distribution of Zipeprol in biological fluids and tissues from two victims of lethal intoxication have been given by using GC-NPD, TLC, and GC/MS (*340*).

A recent report has described the analytical scheme developed for the detection of pancuronium in an attempted murder victim (*341*). A fluorometric assay to determine the activity of pseudocholinesterase in postmortem blood samples as a test for organophosphate poisoning was found to be superior in selectivity and sensitivity to those of conventional pH and spectrophotometric methods (*342*). 2-Mercaptoethanol and its metabolite, 2-mercaptoacetate, were detected by GC and GC/MS in the urine and gastric content of a suicide victim (*343*). The identification by GC/MS of a novel byproduct in the tissue and fluid extracts of a victim of fatal overdoses of the tricyclic antidepressant amoxapine and aspirin has been presented (*344*). Mass fragmentation was used to quantify terodiline in blood and urine from a fatal overdose victim (*345*). An analytical method for the determination of sulfide in brain tissue from victims of hydrogen sulfide inhalation has been described (*346*). Hydroxychloroquine was detected by UV, TLC, and GC/MS in the stomach, small intestine, liver, and plasma of an infant who was a fatal poisoning victim (*347*). Cyclizine was quantified in the blood of an overdose victim by GC/MS and detected in the urine and stomach contents (*348*). Quantification of fluoxetine and its active normetabolite was accomplished by GC-FID, and identification of the compounds was performed by GC/MS in the tissues of an overdose victim (*349*).

Nortriptyline was detected by GC-NPD and GC/MS in the heart blood, femoral blood, and tissue of a suicidal overdose victim, with quantification being accomplished by HPLC (*350*). Azinphos-ethyl concentrations in the blood, urine, and gastric lavage liquid from medical examiner cases were determined by using GC-FID, and GC with thermionic detectors (*351*). Toxicological analyses of biological samples from a sudden death following accidental ingestion showed the presence of chlormequat in the stomach contents and urine (*352*). Fluoxetine concentrations were determined by GC-NPD and GC/MS in blood and bile from a fatal victim whose death was due to fluxetine only (*353*). Carisoprodol and its major metabolite, meprobamate, were determined by GC/MS in the urine, vitreous humor, heart, and femoral blood of three overdose victims (*354*). Flecainide was quantified by GLC-NPD in the blood and other biological fluids and tissues of a victim of fatal flecainide intoxication (*355*).

Disulfoton and its metabolites, two sulfoxides and two sulfones, in the body fluids of a patient who had ingested Di-Syston were analyzed by GC-FPD and GC/MS (*356*). A method for the identification and quantification of hydroxyzine in human body fluids by GC-NPD has been presented (*357*). HPLC was used to determine bone marrow and plasma concentrations of desipramine in rabbits (*358*). GC-FPD and GC/MS were used to detect and confirm the presence of dimethoate from blood samples of a formothion poisoning victim (*359*). An HPLC method has been developed for the rapid quantitative analysis of organophosphorus and carbamate pesticides in postmortem and antemortem biological fluids of pesticide poisoning victims (*360*). A nitrogen selective GC method for the resolution and quantification of phenoperidine and its two metabolites, pethidine (meperidine) and norpethidine (normeperidine), has been described (*361*).

General Procedures. A review and discussion on methodology employed in forensic postmortem cases has been reported (*362*). Quality assurance control samples for urine (*363*) and blood (*364*) for forensic toxicology have been described. The status of drugs of abuse testing in urine under blind conditions has been reported (*365*).

A system for toxicological screening by capillary GC with use of a drug retention index based on nitrogen-containing reference compounds has been described (*366*). A carefully selected reference drug mixture was used to improve the interlaboratory reproducibility of RI values in capillary GC (*367*). Nitroalkanes have been proposed as a multidetector retention index scale for drug identification in GC (*368*). Capillary column GC methods for the identification of drugs of abuse in urine have been described that use liquid–liquid extraction (*369*), liquid–liquid and solid-phase extraction (*370*), solid-phase extraction with a wide-bore capillary column (*371*), and GC-NP detection (*372, 373*).

GC/MS methods for the detection and identification of drugs have been described (*374–377*) as well as the use of

GC/IR/MS for high-confidence identification of drugs (*378*). A direct exposure probe (DEP) mass spectrometric method has been developed for confirmation of drugs of abuse in urine which has been previously screened (*379*). Mass spectra of several commonly abused drugs and their deuterated analogues have been compared and evaluated with emphasis on the selection of suitable ions for selective ion monitoring when the isotopic analogues are used as the internal standards in a quantitative process (*380*).

Methods for the toxicological screening of urine and serum for drugs of abuse by HPLC have been described (*381–383*) as well as actual case applications using HPLC (*384, 385*). Computer-assisted HPLC methods for the automated qualitative and quantitative analysis of toxic drugs have been described (*386, 387*). A review on the application of multiple detectors for HPLC forensic drug analysis has been published (*388*). A sensitive HPLC analysis of basic drugs of abuse having weak UV absorptivity using columns with low carbon loadings monitored at 205 nm has been described (*389*). An international collaborative study between 10 laboratories was carried out to study the reproducibility of the separation of basic drugs on silica columns (*390*).

A technique has been presented for the extraction of free and conjugated drugs and related compounds out of small quantities of urine followed by TLC with special regard to reagents with low toxicity (*391*). A review with 110 references on applications of TLC methodology in drug testing has been published (*392*). A multiple-variable thin-layer and reversed-phase TLC scheme for the identification of basic and neutral drugs has been evaluated (*393*).

A review with 46 references of the comparison of FT-IR spectroscopy with other spectroscopic methods has been reported (*394*). Fourier-transform Raman spectroscopy was investigated as a means of characterizing samples of drugs (*395*).

A review and discussion on the immunotoxic potential of drugs of abuse has been presented (*396*). Studies on the interference of substances in immunoassay methods for drugs of abuse have been reported (*397, 398*). Immunoassay methods for the detection of drugs of abuse have been reported using enzyme immunoassays (*399–404*), RIA (*405–406*), and particle concentration fluorescence immunoassay (*407*).

The enzymic hydrolysis of hair for drug detection has been described (*408*). A review of chiroptical phenomena and the analytical applications including forensic applications of polarimetry, optical rotatory dispersion (ORD), and circular dichroism (CD) has been presented (*409*). CD spectropolarimetry has been used for the determination of drugs of abuse (*410*). The effect of heat treatment of urine for safe handling of samples to be screened for drugs of abuse has been discussed (*411*). Absorption extraction on diatomaceous earth was examined and found to be compatible with typical postmortem blood specimens encountered in forensic toxicology (*412*). Various sampling plans, exhibit sizes, and sample sizes were used as examples in the examination of the validity of the assumption that a sampling plan assumes that the characteristics of the nonexamined units are the same as those in all of the examined units (*413*).

A paper has presented the basic principles and practical benefits of the application of expert systems (ES) and artificial intelligence to problem solving in forensic toxicology (*414*). Maggots have been proposed as a new medium of investigation in forensic medicine for drug detection by HPLC (*415*). Six groups of common drugs of abuse were determined in whole blood after acetone precipitation using EMIT-dau and FPIA methods (*416*).

TRACE EVIDENCE

Petroleum Products. An accelerant classification scheme that takes into account the chemical nature of the accelerant and boiling ranges was developed for examining accelerant residues by GC/MS (*417*). The identification of liquid gasoline production lots may be carried out by examining gas chromatograms of low boiling constituents. However, highly weathered samples cannot be individualized to a particular lot (*418*). The use of GC/MS for detecting accelerant in fire debris has been reviewed (*419*). The direct comparison of mass spectral ion chromatograms obtained from an isolate of a suspect fire debris sample with the corresponding GC headspace profiles of known accelerants has been automated (*420*). A simple, inexpensive carbon wire absorption/solvent extraction technique that allows for sensitive and reproducible analysis of organic volatiles from arson debris has been described (*421*). Charcoal has the ability to retain selective aromatics at the expense of aliphatics, thus modifying the gas chromatogram pattern for turpentine (*422*). Methods for recovery of residual accelerants in fire debris were reviewed (*423*). Infrared spectroscopy provided a useful method for matching samples of petroleum products (*424*). It was found that three-dimensional fluorescence spectroscopy is able to differentiate midrange petroleum products such as charcoal lighters and pain thinners. Evaporated products produced reproducible and characteristic fluorescence spectra (*425*). Gasoline in soil samples stored at room temperature was shown to rapidly degrade. Freezing was shown to be an effective way to prevent microbial degradation (*426*). The persistence of gasoline and kerosene on various unburned substrate materials was measured. Evaporation rates were found to be dependent on the volatility of the accelerant, surrounding temperature, and absorption characteristics of the substrate (*427*). Automotive lubricants and stains could readily be identified or discriminated by isotachophoresis (*428*).

Explosives. A colloborative study of an extraction method for determining nitro aromatics and nitramine explosives in soil was reported (*429*). An electrical circuit modification has made a GC thermal energy analyzer fully compatible with the resolving power of capillary GC for the detection of traces of explosives (*430*). Capillary supercritical fluid chromatography with thermal energy analysis was shown to be applicable to the analysis of trace quantities of explosives. The detection of nitramines, nitrate esters, and nitro aromatics was discussed (*431*). Collision-induced dissociation spectra of five synthetic nitramines were obtained (*432*). The use of anion chromatography on polymeric packing materials permitted the detection and quantitation of nitrite and nitrate anions in hydrolysates formed by heating nitrocelluloses, nitroglycerine, and gunshot residues (*433*). The potential of ion mobility spectrometry as a sensitive method for detecting hidden explosives and contraband drugs has been reviewed (*434*).

Gunpowder and Primer Residue Detection. Data on gunshot residue (GSR) analysis were obtained from a survey of 200 U.S. forensic laboratories (*435*). A study of suicide cases in which gunshot residue tests were conducted revealed a GSR-consistent opinion 38% of the time. Cases in which hands were not safeguarded resulted in low positive test results (*436*). Barium and antimony levels from selected areas of the left and right hands of nonshooters were examined to provide a data base for the interpretation of gunshot residue swab analysis results (*437*). Modifications were made to a previously reported extraction procedure for determination of antimony, barium, and lead in gunshot primer residue swab extracts (*438*). Swabbing kit containers have been developed with which a solid phase extraction can be carried out. This approach is applicable for both firearm and explosive residues (*439*). Plasma ashing has been used for the removal of organic debris from the adhesive tape employed for collecting GSR particles on the hands (*440*). A statistical analysis was presented to evaluate the specimen area to be searched for GSR by scanning electron microscopy/energy dispersive X-ray analysis (SEM/EDX) analysis. It was concluded that statistical considerations may not provide sufficient justification for evaluating the sample area to be searched (*441*). The most efficient way of detection GSR particles by SEM/EDX is by using an automated search routine on glue-lifted samples without any pretreatment (*442*). A dynamic headspace method by GC with thermal energy analysis detection was reported for the improved cleanup of gunshot residues prior to the detection of nitroglycerine (*443*). An HPLC procedure for the detection of gunshot residue on the hands of a firer was developed. The procedure required the detection of nitrocellulose and organic stabilizers (*444*). In order to improve the reliability of a gunshot residue test on hands, commercial cartridges were labeled with samarium oxide. This approach was demonstrated to be an effective way of identifying a shooter (*445*). The combined use of IR microspectrophotometry and GC/MS was used to characterize smokeless powder propellants (*446*). Smokeless powder propellants were analyzed by pyrolysis capillary gas chromatography. Relatively minor differences existed between the pyrograms of smokeless

powder from different manufacturers (*447*). The detection of molten gunshot residue particles on hair and polyester fabrics indicates a close proximity shot (*448*). Chemical and spectroscopic techniques used for the determination of shooting distance have been reviewed (*449*).

Paint and Glass. A system for identifying automobiles according to paint color and layer sequence was reported (*450*). An assessment was made of the usefulness of microspectrophotometry for identifying automobile paints. This was achieved by measuring the tristimulus values of a collection of known automobiles. These values compared favorably to data from a reference collection of standard colors (*451*). A study has been undertaken for identifying vehicles involved in hit and run accidents from color measurement of retrieved point fragments. It has been demonstrated that accurate comparisons between paint fragments and reference sample can be accomplished by microspectrophotometry (*452*). The use of microspectrophotometry in the examination of paints has been reviewed (*453*).

The advantage of using thin sections of paint in forensic examinations has been described (*454*). Diffuse Reflectance infrared Fourier transform spectroscopy (DRIFTS) has been used to analyze metallic automobile paints. The density of the metallic flakes used in the paint is the primary factor determining the applicability of this method (*455, 456*). A pyrolysis gas chromatography system employing a Curie point pyrolyzer, an inlet splitter, and a stationary phase of intermediate polarity has been developed. Capillary GC was found to be superior to a packed column for the identification of paint resins (*457*). A testing protocol for elemental analysis of automative paint by SEM/EDX based on beam alignment by current centering and using an attached optical microscope was developed to improve the reliability of sample comparisons (*458*). The Chelsea filter provides an extremely useful method for the characterization of paint pigments (*459*). The microanalysis of paintings was used to determine authenticity (*460*).

A glass annealing method has been reported that results in the separation of tempered glass from other common glass types (*461*). A criterion has been proposed to ascertain whether two or more glass specimens originated from the same source. The proposal requires determining the slope of a plot of dispersion versus density (*462*). A simple method has been described to convert the flat microscope slide into an improved sample holder for refractive index determinations of small glass fragments (*463*). Inductively coupled plasma mass spectrometry was used to characterize window glass. Tests performed produced successful discrimination levels higher than 85% for the glass samples investigated (*464*). The application of Bayesian inference to the interpretation of glass evidence has been discussed in the context of hypothetical glass-on-clothing cases (*465*). The observation of dark and light bands in glass fragments has been investigated with respect to its usefulness in forensic examinations. The origin and nature of the bands remain unclear, but they appear to be related to the manufacturing process, with the bands probably representing regions of different composition and refractive index. It was found that the variation in the pattern of the bands could be used to demonstrate the origin of a glass fragment (*466*).

Hairs and Fibers. If two hairs are microscopically indistinguishable, the probability of an incorrect association is remote (*467*). The value of head and pubic hair transfers between persons and objects in sexual assault cases has been demonstrated (*468*). Oxidative dye brands used on hair can be identified by GC, GC/MS, pyrolysis GC, and pyrolysis GC/MS (*469*). Components of women's hair care products were detected on hair by GC and GC/MS (*470*). The components of some hair sprays and growth promoters were detected on hair by GC as long as 24 h after treatment (*471*). Washing hair with shampoo results in an accumulation of shampoo components in the hair. Hair of individuals using different shampoos was distinguished by using HPLC (*472*). The influence of weathering and cosmetic treatment has been studied on the electrophoretic patterns of human hair proteins (*473*). In a Japanese population, a significant number of individuals had head hairs showing a high-sulfur protein band variants by electrophoresis (*474*). Hair protein variations based on genetic or acquired origin have been reviewed with special reference to forensic hair comparisons (*475*). A study indicates that with many different breeds of dogs some degree of individualization based on hair examination is possible (*476*). A method for differentiating cat and dog hair has been described (*477*). Human head hairs were analyzed by pyrolysis gas chromatography. The pyrograms showed some components that differed significantly among individuals. Further study will be required to establish the usefulness of this technique to personal identification (*478*).

Methods for preparing fiber cross sections have been described (*479*). The utility of fiber cross sections in forensic examinations has been explored (*480*). Spectra of single synthetic fibers are obtained by infrared microscopy. An IR spectral library of fibers was constructed (*481*). The transfer of acrylic fibers simulating real life conditions was described. These fibers were shown to persist on a variety of garments after they had been washed or dry cleaned (*482*). The potential of using a combination of normal and reversed-phase thin-layer chromatography for the comparison of textile fiber dyes was examined. Reversed-phase systems were found to be satisfactory for the separation of disperse and acid dyes (*483*). Commercially available TLC tanks and plates were evaluated for their abilities at separating a variety of fiber dyes (*484*). For azoic dyes extracted from cotton fibers, the most favorable TLC developing system is chlorobenzene:1,2-dichloroethane:acetone (20:20:1) (*485*). A scanning densitometer was used to provide information about a fiber dye separated by TLC (*486*). Microspectrophotometry yielded a very small number of matching spectra from different dyes on each color class of blue, red, and black cotton fibers. An added examination by TLC yielded no general conclusion regarding its value as a test for providing an extra level of discrimination (*487*). A review of the principle methods for developing fibers as forensic evidence has been published. The relevant literature in the time period 1950–1987 is included (*488*).

Fingerprints. Latent fingerprint development detection using laser excited luminescence has been reviewed (*489*). Pretreatment procedures for laser detection of latent fingerprints have been reviewed (*490*). An industrial chemical marketed by Ardrox, Ltd., was used as a luminescent stain to enhance cyanoacrylate processed fingerprints (*491*). A solution known as "Physical Developer" has been demonstrated to react with lipids and has visualized fingerprints on materials that were as old as 30 years. Physical developer is recommended for developing latent prints on specimens that are or have been wet (*492*). The forensic applicability of 1,8-diazafluoren-9-one (DFO), which produces a highly fluorescent species with latent fingerprints on paper, has been reported (*493*). The reaction of *o*-phthalaldehyde with latent fingerprint residues has been found to be quite sensitive, forming highly luminescent reaction products that can be visualized by using blue-green wavelengths (*494*). 7-Benzylamino-4-nitrobenz-2-oxa-1,3-diazole (BBD) and 7-(*p*-methoxybenzylamino)-4-nitrobenz-2-oxa-1,3-diazole (MBD) have been shown to cause latent prints fumed with cyanoacrylate to fluoresce brightly (*495*). Small particle reagent is an effective reagent for detecting the presence of latent fingerprints on water-soaked items. It comprises a suspension of molybdenum disulfide powder. Experiments have shown this reagent to be effective in processing wet firearms for fingerprints (*496*). A small particle suspension of iron oxide black powder has been formulated for developing latent fingerprint on smooth surfaces. This new reagent was found to be a superior to small particle reagent (a molybdenum disulfide suspension) (*497*).

A model has been proposed to explain the structural and photophysical features of metal–Richemann's purple coordination compounds. The application of these complexes to the detection of latent fingerprints was discussed (*498*). Intramolecular energy transfers in europium–Richemann's purple complex has been examined and applied to the detection of latent fingerprints (*499*). A gaseous electrical discharge followed by treatment with vapors formed by heating ammonia in hydrogen carbonate produced UV excited luminescence in latent prints (*500*). The process of the aging of fingerprints has been reviewed (*501*).

Miscellaneous. The results of a study suggest that a sample size of 100 mg could be the limit of repeatable sample in determining particle size distribution of soils. Furthermore, the results suggest that the inherent limitations in particle size distribution analysis are a function not of instrumental

error but of sampling ability (*502*). A method involving simultaneous pyrolysis–alkylation–gas chromatography was applied to the characterization of a range of polyesters, phenolic resins, and polymer additives (*503*). Pyrolysis GC was used to identify trace rubber residues from shoe soles and tires (*504*). Plastic automobile bumper bars have been examined by using Fourier transform infrared spectroscopy (FT-IR), pyrolysis gas chromatography (PGC), and SEM-EDX (*505*). Plastic sidelights from vehicles were identified by IR. TLC of the dyes extracted from the lights helped distinguish similarly colored sidelights (*506*). A review of the utility of trace evidence recovered from spent bullets has been presented (*507*). A solvent consisting of a mixture of aliphatic and halogenated hydrocarbons has been used to separate and unravel adhesive tapes (*508*). A study involving a range of possible weapons, clothing types, and types of damage showed that it is possible to distinguish a cut from a tear and a slash from a stab (*509*). A series of experimental stab–cuts was made by using three knives and a variety of clothing. It was concluded that stab–cut dimensions in clothing do not accurately reflect the knife blade width (*510*). SEM micrographs were obtained for fiber ends of a nylon fabric that had been experimentally cut with a scalpel or scissors or torn by force. In the nylon fabric used, these three types of damage were identifiable on the basis of features of the fiber ends (*511*). Limitations in the determination of calcium/phosphorus using SEM and EDX were discussed. Implications for the identification of bone fragments were highlighted (*512*).

Inks were distinguished by adsorption chromatography on cellulose (*513*). A mass-independent procedure that under certain conditions can be used to estimate reliability the age of most ballpoint and some nonballpoint inks has been described. This TLC procedure can estimate the age of some inks up to 5 years after a document has been written (*514*). Electrostatic detection has been used to develop writings written with secret inks (*515*). The dye compositions of ink pads have been determined by TLC (*516*). Mass spectrometry was used to compare photocopy toner material from photocopies (*517*). The analysis and differentiation of photocopy toners has been reviewed (*518*). FT-IR was utilized to characterize a variety of correction fluids according to their binder/pigment content (*519*). Ridge patterns appearing on the fingernails of a pair of twins were compared and found to be readily indistinguishable (*520*). A study was designed to identify stains derived from plant pigments. By using HPLC, 12 flavornoids were detected in plant stains (*521*). Photographic techniques have been shown to useful for the comparison of brake and accelerator automobile pedals with marks on shoe soles (*522*). A study to investigate the retention of bloodstains on fabrics after washing was undertaken (*523*). A series of chemical reagents have been used to enhance bloody imprints on cloth and paper surfaces. The reagents selected for this comparison include rhodamine dye, luminol, and coomassie blue stain (*524*).

Probability considerations have been evaluated in determining the significance of physical evidence (*525*). A Bayesian approach to evidence evaluation has been described. The discussion is based on an example that involves the presence of blood on the clothing of a man who is suspected of stabbing another man (*526*). Computational procedures based on probabilities for incorporating and assessing evidence obtained in the course of a criminal investigation have been described (*527*).

FORENSIC BIOCHEMISTRY

A study was designed to analyze the effects of common environmental insults on the ability to obtain deoxyribonucleic acid (DNA) restriction fragment-length polymorphisms (RFLP) patterns from laboratory prepared specimens. The environmental conditions studied include the exposure of dried bloodstains to varying amounts of relative humidty, heat, and ultraviolet light for periods of up to 5 days. The results of the study showed that, under the conditions studied, the integrity of DNA is not altered such that false RFLP patterns are obtained (*528*). It has been demonstrated that DNA of sufficient quality and high molecular weight can be reliably isolated from bloodstains deposited on evidentiary items which have an unknown environmental history and which have dried onto a variety of substrata (*529*). DNA typing using blood from a victim and the victim's parents was used to establish the identity of decomposed human remains (*530*). DNA fingerprinting using repeat oligonucleotide probes has been evaluated and shown to be applicable to forensic specimens (*531*). Data have been presented to support the use of five minisatellite probes in paternity and forensic investigations (*532*). VNTR markers have been successfully used for paternity testing (*533*). Reliable and reproducible protocols have been developed for DNA fingerprinting using minisatellite probes 33.15 and 33.6 (*534*). A minisatellite probe, M21.3, has been applied to DNA fingerprint analysis (*535*). DNA typing of blood samples using multilocus probes proved to be informative in paternity testing where traditional methods yielded inconclusive or insufficient results (*536*, *537*). DNA fingerprinting was used to link semen in a condom found beside a female victim to the blood of the suspect (*538*). Hybridization and subsequent washing steps were refined to improve the sensitivity of DNA fingerprints obtained with a biotin-labeled M13 probe (*539*). With the use of biotinylated M13 phage as a probe for hypervariable minisatellite, it was possible to obtain highly individual specific DNA fingerprints (*540*). A DNA fingerprint method using a nonradioactive sulfonated DNA probe has been described (*541*). A nonisotopic DNA probe has been successfully used to distinguish human blood stains from other animals (*542*). The utility of DNA fingerprinting has been evaluated for a Japanese population (*543*). The probabilistic basis for evaluating the significance of a DNA banding pattern has been discussed (*544*). DNA profiles derived with multilocus probes for a mother, child, and puntative father have been described (*545*). A statistical approach to multilocus DNA paternity analysis was presented where partial DNA profiles exist (*546*). A biostatistical evaluation of DNA probe evidence in the case of disputed paternity has been presented. The evaluation has been restricted to single-locus systems (*547*). DNA analysis using two probes, YNH24 and CMM101, was performed by using a commercial system for electrophoresis, Southern blotting, hybridization, and autoradiography (*548*). Population studies were performed by using DNA probes that recognize five hypervariable loci (D2S44, D14S1, D14S13, D17S79, and DXYS14) in human genome (*549*). Quantification of DNA in forensic extracts of biological samples was accomplished by hybridization to DNA probe D17H8 (*550*). The feasibility of using DNA extracted from bloodstains for the detection of DNA polymorphisms was explored by using a haptoglobin α chain specific probe (*551*). The effects of endogenous 5-methylcytosmes on DNA typing were studied by using methylation sensitive restriction endonucleases (*552*).

Human bloodstains were identified with a radioactive DNA probe (*553*). DNA extracted from teeth was successfully characterized by using a labeled minisatellite DNA probe and a Y specific DNA probe (*554*). A human sex determination method from dried bloodstains was developed by using biotin-label probes containing a male specific sequence (*555*). A recombinant DNA probe (HY10) was used for sex determination of degraded DNA samples of bloodstains. Reliable sex determination was made from stains greater than 20 years old (*556*). An asymmetric ribonucleic acid probe, which represents a Y chromosome specific nucleotide sequence, has been applied to determine the sex origin of bloostains (*557*). A method has been described for the sex identification of a bloodstain using a Y chromosome specific DNA probe (*558*). Procedures were developed to optimize the recovery of DNA from forensic samples (*559*). Advantages of using *Hae*III as a restriction endonuclease for restriction fragment length polymorphism analysis of forensic science samples has been reviewed (*560*). A strategy for identifying VNTR/restriction site polymorphisms and determining their component allelic fragments has been demonstrated (*561*). A number of VNTR data bases studied showed no consistent evidence of a violation of the Hardy–Weinberg test (*562*). A computerized system has been used to store DNA profiles from three hypervariable loci. This study indicates that band matching is only possible after analysis of the errors associated with electrophoretic systems (*563*).

A genetic locus (D1S58) that contains a variable number of tandem repeats has been successfully amplified by polymerase chain reaction (PCR) and should prove useful for forensic determinations (*564*). Separation of PCR amplified fragment length polymorphisms was carried out by poly-

acrylamide electrophoresis (*565*). Allele and genotype frequencies at the HLA-DQ α locus have been determined by the use of PCR (*566*). Polymerase chain reaction amplification of Y chromosome specific DNA enabled a rapid and reliable sex determination of bloodstains and hair to be accomplished (*567*). Amplification of the hypervariable region close to the apolipoprotein B gene was accomplished by PCR on bloodstains (*568*). An image analyzer was used to store and analyze data derived from autoradiographs of DNA profiles (*569*). Underlying concepts of forensic DNA typing procedures have been reviewed (*570, 571*). The application of PCR to forensic science was reviewed (*572–574*). Forensic aspects of blood typing, protein polymorphisms, and DNA typing were reviewed (*575*).

An electron spin resonance method for detecting bloodstain has been reported (*576*). An enzyme-linked immunosorbent assay (ELISA) technique using human haptoglobin antibodies was used to identify human blood (*577*). By applying the ELISA technique using a monoclonal antibody, a new species identification method with improved sensitivity and specificity was devised. In this manner, human origin was readily determined in bloodstains (*578*). Various animal keratins have been examined by electrophoresis as a means for performing species identification (*579*). Progesterone and lutenizing hormone levels were detected in bloodstains for the purpose of establishing pregnancy (*580*). Human chorionic gonadotropin has been detected in bloodstains by using an immunoassay technique. Detection of this hormone in bloodstains is of special interest for pregnancy diagnosis in forensic science applications (*581*). Buffer systems have been described for lactate dehydrogenase electrophoresis for the purpose of characterizing menstrual blood (*582*). Several bands of EAP and PGM activity were detected in animal bloods. PGM bands appearing outside the human band areas could be used as markers for the possible presence of animal blood (*583*). An X-ray dose of 25 000 rad was shown to be sufficient to inactivate HIV in blood specimens and body fluids that may be submitted to a forensic science laboratory for examination and analysis. This method cannot be used on body fluids that will be subjected to DNA typing (*584*).

Fungi have been isolated from soil, which act on A and B red blood cells (*585*). Contaminating antibodies in an antiserum may produce unexpected reactions in countercurrent immunoelectrophoresis at low antigen concentrations (*586*). Validation studies of a sensitive microplate hemagglutination assay for ABO reverse grouping have been carried out. On the basis of these studies, the microplate assay has replaced the Lattes crust test for ABO reverse grouping of bloodstains in the FBI laboratory (*587*). A method based on immunocytochemistry has been reported that permits ABH and MN antigen determinations on bloodstains without special fixation (*588*). Studies with monoclonal antibodies demonstrated that different epitopes exist in red cell and body fluid ABH antigens. This observation suggest the need to use different monoclonal antibodies to discriminate ABH antigens in red cells from those in other body fluids (*589*). The rapid detection of ABO antigens in body fluids and stains was accomplished by using ABH enzyme-labeled monoclonal antibodies and dot-ELISA (*590*).

The use of chemically modified indicator erythocytes enhanced the sensitivity for hemagglutination reactions (*591*). Evidence has been presented for the rare transmittance of a "silent" allele at the MN blood group locus in a Caucasian family (*592*). A technique was developed for Gm/Km typing of bloodstains using U-bottom microtiter plates (*593*). A stability study comparing the identification of κ marker Km(1) using the classical inhibition of agglutination and the identification of Km(3) using an automated ELISA technique were reported (*594*). Phenotype frequencies have been reported for the immunoglobulin allotypes G1m (1,2,3) and G3m (10,21) (*595*).

Two subtypes FA and FB of the BF·F allele have been detected. The allele frequencies of these subtypes were determined (*596*). Human hemoglobin A and F antigens were detected in human bloodstains by a latex agglutination inhibition test (*597*). A method has been reported for the classification of different C/R genetic variant forms from human serum or plasma (*598*).

The performance of polymorphic genetic marker systems in bloodstains was evaluated. Based on the results of sensitivity and stability trials, group specific component (Gc) phenotyping should be the first choice followed by phosphoglucomutase (PGM), α-2-HS-glycoprotein (A2HS), haptoglobin (Hp), and erythrocyte acid phosphatase (EAP) (*599*). α-Antitrypsin, transferrin (Tf), and orosomucoid I (ORM) were determined in bloodstains by isoelectic focusing (*600*). A nonequilibrium isoelectric focusing method was developed that reliably discriminated common and rare phenotypes of EsD, EAP, PGM, adenylate kinase (AK), and adenosine deaminase (ADA) isoenzyme systems (*601*). The advantages of determining EAP phenotypes on ultrathin gels by isoelectric focusing have been summarized (*602*). PGM and EsD typing on ultrathin polyacrylamide gels using nonequilibrium pH gradient electrophoresis was carried out (*603*). Nonequilibrium isoelectric focusing was used to simultaneously determine EAP and EsD phenotypes in bloodstains (*604*). Aged bloodstains were successfully phenotyped for EAP and EsD by isoelectric focusing under nonequilibrium conditions (*605*). Phenotypes of EsD, PGM, and the ABO systems were simultaneously determined (*606*). Glyoxalase I (GLO) electrophoretic band patterns may develop an additional band when a bloodstain has undergone some heat denaturation (*607*). Anti-PGM antibodies have been produced and used to devise an immunological procedure for detecting PGM isoenzymes (*608*). Gene frequency distributions were reported for ABO, PGM, EsD, EAP, AK, and ADA blood group markers (*609*). Phenotypic and genotypic frequencies have been determined for ABO, Lewis, EsD, PGM, AK, ADA, and Hp systems (*610*). Except in the case of relatively fresh bloodstains, the 6-phosphogluconate dehydrogenase (PGD) enzyme seems not to be very suitable under Indian climatic conditions (*611*). PGD has been typed in bloodstains, organ tissues, dental pulps, and hair roots by isoelectric focusing (*612*). Haptoglobin phenotyping of bloodstains by horizontal electrophoresis on a compact polyacrylamide gradient gel was reported (*613*). Haptoglobins were typed in bloodstains. It was possible to correctly determine haptoglobin phenotypes of 2-year-old bloodstains (*614*). The detection of Gc in bloodstains by isoelectric focusing has been described. The Gc proteins were transferred from the electrophoresis gel to nitrocellulose and detected with goat anti-GC followed by peroxidase-labeled anti-goat immunoglobulin antibody (*615*). Casework bloodstains were typed for Gc at eight forensic science laboratories. Gc was shown to be an effective genetic marker in forensic investigations (*616*). Eight forensic science laboratories successfully typed 393 and 400 bloodstains for the Gc system, indicating that Gc in bloodstains can be typed reliably (*617*). A sensitive immunoblotting method for the detection of Gc in bloodstains has been developed. The method shows a 4-fold increase in sensitivity when compared to immunofixation and silver staining (*618*). Gc phenotyping of bloodstains was accomplished by electrophoresis (*619*). An isoelectric focusing method has been used to detect Gc in bloodstains. Gene frequency data has been collected (*620*). An isoelectric focusing technique for the simultaneous determination of C6 and C7 types in bloodstains was reported. Population data for these types in a Japanese populations were developed (*621*). C3 was determined in bloodstains by isoelectric focusing. Beyond 2 weeks of storage, bloodstains are difficult to C3 phenotype due to decreasing band intensity (*622*). ORM phenotypes were determined in bloodstains by isoelectric focusing (*623*). Typing of G3MT by dot blots was carried out with a monoclonal antibody (*624*). A2HS has been detected in bloodstains by an isoelectric focusing procedure (*625*). An immunoblotting procedure has been developed for the detection of A2HS phenotypes in bloodstains. A2HS gene frequencies were determined from a survey of 1000 people in Australia (*626*). Gene frequency studies for uridine monophosphate kinase and aminolevulinate dehydrase have been carried out (*627*).

The numbers and types of sexual offenses examined through the Metropolitan Police Forensic Science Laboratory (London) during 1978–1986 were presented (*628*). Using Proteinase K, it is possible to digest all the cellular material apart from spermatozoa in the aqueous extracts of vaginal swabs (*629*). The values of using a zinc color spot test as a means of identifying seminal stains was investigated. The specificity of the test for semen was shown to be higher than that of an acid phosphatase spot test (*630*). A fast moving acid phosphatase variant was identified from various semen

stains (631). An immunoassay test using monoclonal antibody was devised for the detection of p30. In vaginal swabs, p30 was detected 24 h postcoitus (632). The advantages of this assay for the detection of p30 over the search for spermatozoa and prostatic acid phosphatase was discussed (633). The identification of seminal vesticle specific antigens by a dot-ELISA method in seminal stains was demonstrated (634). An ELISA assay has been developed for the detection of semen specific 19-OH prostaglandin F12/F22 (PGF) (635). Case work analysis of swabs and stains indicates that PGF represents a useful method for the identification of semen and is particularly valuable where spermatozoa are absent (636). The measurement of PGF on swabs and in stains was shown to give a specific and sensitive indication of the presence of human semen (637). The levels of PGF are equivalent in the semen of vasectomized, infertile, and normal men (638). A monoclonal antibody which recognizes a human sperm-coating antigen which is specific to human seminal plasma has been used to detect human semen stains (639). The relationship between components found on vaginal swabs was examined to determine whether the presence and quantity of a particular component could be used to predict the presence of others. Grouping results could not be related to the concentration of spermatozoa, acid phosphatase, or p30 (640). Semen stains were typed for the ABO and Lewis systems using a dot-ELISA technique (641). The use of monoclonal antibodies for detecting secreted ABH blood group substances in semen and saliva was studied. The results demonstrated that the behavior of some monoclonals were unpredictable and often failed to detect the corresponding antigen (642). An ELISA method for detection of ABO blood substances in semen was reported (643). Peptidase A was successfully typed in dried blood and semen stains by electrophoresis (644). Orosomucoid I phenotypes were detected in seminal plasma by isoelectric focusing. Semen stains stored for 10 days could be typed for orosomucoid I (645). Isoelectric focusing was used for the simultaneous identification of α-L-fucosidase and PGM in semen. Gene frequencies of α-L-fucosidase were determined (646). A method for the separation of diaphorase isoenzymes in semen stains has been reported (647). Phenotypes of human semen diaphorase was studied by isoelectric focusing, and their gene frequencies were determined (648).

Concentration levels of fructose, sialic acid, and glycerophosphorylcholine was found useful for differentiating the seminal stains of azospermic, normospheric, and vasectomized persons (649). A survey has been made to assess the evidential value of tests carried out on penile swabs (650). Detection of ABO blood group substances in trace quantities of saliva stains was accomplished by ELISA with the use of monoclonal antibodies (651). The detection of ABO and Lewis phenotype in human saliva was accomplished with a dot-ELISA method using monoclonal antibodies (652). Lewis grouping of human saliva stains has been performed with an ELISA assay using monoclonal antibodies (653). Uric acid and urea nitrogen were shown to be useful for the identification of human urinary stains (654). Human origin of aged urine could be demonstrated by uric acid and urea nitrogen content as well as human uromucoid levels (655). Urine samples were concentrated and ABO typing on the concentrated samples was successfully performed (656). Gc markers in human urine were detected by isoelectric focusing (657, 658). Orosomucoid I polymorphisms were detected in urine by isoelectric focusing (659). Polymorphisms of transferrin were detected in urine by isoelectric focusing. Gene frequencies were determined (660). A, B, and H group substances were determined in the vitreous humor of human corpses (661).

A procedure consisting of the use of both absorption elution and absorption inhibition yielded reliable grouping data on bone tissue (662). By using ultrathin polyacrylamide gel isoelectric focusing, EAP phenotypes were determined in human hair root sheaths (663). An immunoenzyme method was used to detect ABO blood group antigens in fingernails (664). EsD, GLO, GPT, and PGP enzymes in perserved muscle tissue were demonstrated (665). HLA class I and class II antigens were detected in extracts of dry spleen tissue (666).

BOOKS

There have been some noteworthy books published on forensic science topics since 1988. *Analytical Methods in Forensic Chemistry* (667) provides an assessment of current applications of future directions of analytical methods in forensic chemistry. *The Scientific Examination of Documents: Methods and Techniques* (668) describes methods and techniques required to provide information of forensic value from documents. A thorough review of footwear evidence and tire evidence is to be found in *Footwear Impression Evidence* (669) and *Tire Imprint Evidence* (670), respectively. Various aspects of bloodstain evidence are detailed in *Interpretation of Bloodstain Evidence at Crime Scenes* (671). The increasing importance of DNA within forensic science is reflected in a variety of new books on the subject: *DNA and Other Polymorphisms in Forensic Science* (672), *DNA in Forensic Science: Theory, Techniques and Applications* (673), *Genetic Witness: Forensic Uses of DNA Tests* (674), *DNA Fingerprinting: An Introduction* (675), *Forensic DNA Technology* (676), *Proceedings for the International Symposium on Human Identification*; Data Acquisition and Statistical Analysis for DNA Typing Laboratories (677), and *Banbury Report 32: DNA Technology and Forensic Science* (678). DeHaan has revised the popular *Kirk's Fire Investigation* (679), and a 4th edition of the introductory text, *Criminalistics: An Introduction to Forensic Science* (680) has been published along with *Lab Manual for Criminalistics* (681). A number of books have been published containing the proceedings of symposia on various forensic science topics held under the suspices of the FBI. *Proceedings of the International Symposium on Driving Under the Influence of Alcohol and/or Drugs* (682), *Proceedings of the International Symposium on the Forensic Applications of Digital Image Processing* (683), *Proceedings of the International Symposium on Forensic Immunology* (684), and *Proceedings of the International Symposium on the Forensic Aspects of Controlled Substances* (685) contain relevant review and research articles on topics of forensic interest. Baselt and Cravey have published the 3rd edition of the important forensic toxicology reference text *Disposition of Toxic Drugs and Chemicals in Man* (686). Also available is the 2nd edition of *Analytical Procedures for Therapeutic Drug Monitoring and Emergency Toxicology* (687). Relevant review and research articles on forensic toxicology can be found in *Advances in Analytical Toxicology*, Vol. 2 (688), and *Forensic Toxicology: Proceedings of the 25th International Meeting of the International Association of Forensic Toxicologists* (689). Sunshine's *1989 Year Book of Toxicology* (690) and *1990 Year Book of Toxicology* (691) review important published research papers in forensic toxicology.

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