FORENSIC SCIENCE

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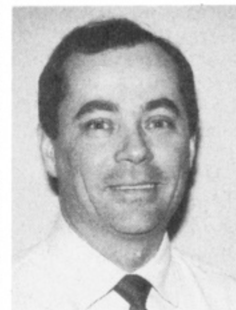

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It is the aim of this article to present a concise survey of articles appearing in publications that primarily appeal to forensic practitioners. To accomplish this objective, we have focused our attention on the following journals: *Journal of Forensic 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 January 1991 through December 1992. 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: drug 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. The between-run accuracy and reproducibility of vapor alcohol control tests associated with quantitative evidential breath alcohol testing in the field has been evaluated using the TOXITEST II breath alcohol simulators and the Model 5000-D Intoxilyzers in the recirculation mode (*1*). Exemplars of current common breath alcohol simulators were studied to ascertain their suitability for control tests and as calibrators in breath alcohol analysis (*2*). An evaluation of the Drager Alcotest 7110 showed that the instrument has been properly shielded from radiofrequency interference and that its discrimination against acetone exceeds the manufacturer's specifications (*3*). An experimental setup for legally acceptable breath alcohol determinations has been proposed consisting of two independently operating IR breath analyzers operating at absorption wavelengths of 3.4 and 9.2 μm, which are connected to a single microcomputer (*4*). The effect of breath alcohol simulator solution volume on the measurement results has been studied using a BAC Verifier Datamaster (*5*). The advantages and especially the disadvantages of breath alcohol analysis for determining blood alcohol concentrations (BAC) from a forensic viewpoint in relation to an expert opinion of

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the Federal German Health Administration has been reviewed (*6*). Actual field data from subjects arrested for DWI was compared to breath alcohol analysis and its relevance was discussed as to the issue of retrograde extrapolation (*7*). The variability of measuring ethanol in blood and breath for legal purposes between laboratories and between breath test instruments has been studied (*8*). The mathematical modeling of the elimination rate of mouth alcohol and its implications in breath alcohol analysis has been discussed (*9*). A study on the effect of dentures and denture adhesives on mouth alcohol retention showed that denture use, both with and without the concurrent use of adhesives, does not significantly affect breath alcohol concentration as long as a pretest alcohol deprivation period of 20 min is observed (*10*). BAC and time to peak BAC were determined in venous blood samples and Breathalyzer readings from subjects who ingested a large quantity of alcoholic beverages within a short drinking time span (*11*). Diethyl ether vapor interference was investigated using instruments based on infrared absorption at 9.5 μm (*12*). Headspace gas chromatography (HSGC) of forensic stored blood and urine samples showed the presence of ethyl acetate and toluene, which originated from glue (solvent) abuse ("sniffing") and which caused anomalies in the determination of breath alcohol concentration levels using IR absorption-based forensic breath analyzers (*13*). An investigation on the ALERT J3A, Breathalyzer Model 900A, and the Mark IV GC Intoximeter showed that the 15-min waiting period, currently in use with respect to mouth alcohol, will eliminate any potential interferences caused by asthma inhalers on these systems (*14*). Measurements of "apparent" breath alcohol levels from two individuals who sprayed cars with paints under normal working conditions without the use of protective clothing or face masks were carried out on a Lion Intoximeter 3000 evidential breath analyzer and showed no long-term postspraying retention of solvents in the breath (*15*). The effect of drinking ethanol on breath acetaldehyde levels has been studied (*16*). The background and legislation concerning compulsory breath alcohol testing of suspect motorists in The Netherlands has been reviewed (*17*).

The determination of ethanol in postmortem specimens has been done by using wide-bore capillary gas chromatography (GC) (*18, 19*), and the distribution of ethanol in postmortem blood specimens has been reported using GC (*20*). The analysis of ethyl alcohol concentration in blood using a gas chromatograph equipped with a blood gas sampler was compared to the headspace method (*21*). The peak blood ethanol concentration and the time of its occurrence after rapid drinking on an empty stomach has been investigated (*22*). BAC from 16 healthy men was determined by an enzymatic method in an evaluation of blood ethanol profiles after consumptions of alcohol together with a large meal (*23*). Blood ethanol profiles were determined in healthy volunteers after they had drunk beer (*24*). Ethanol elimination rates with special reference to the forensic calculation of maximal BAC values were measured in male alcoholics over a period of several hours during the postabsorption phase (*25*). The distribution of ethanol and water between plasma and whole blood was determined by HSGC (*26*). The effect of ambient temperature, surface area, and the volume of samples on the evaporation of ethanol was examined in bovine serum and water, and these studies were related to the ethanol concentrations in the blood collected at accident scenes (*27*). A study on the relationships between the BAC and the cause of death has been reported (*28*).

Quality assurance (accuracy, precision) in forensic blood alcohol determinations has been studied in reference to the compliance of new traffic legislation concerning maximum permissible blood ethanol values in Germany (*29*). Chromatographic methods for blood alcohol determination have been reviewed (*30*). A highly sensitive reversed-phase high-performance liquid chromatographic (HPLC) method for the determination of ethanol and methanol in plasma, using a postcolumn enzymic reactor with electrochemical detection has been developed (*31, 32*).

Critical evaluations of the ETS-PLUS Ethyl Alcohol Assay (EMIT) have been reported (*33, 34*), and a modification of both the Syva EMIT-st Urine Ethyl Alcohol Assay and the Sigma Diagnostics Alcohol in Urine Assay for use with the Monarch 2000 Chemistry System has been described (*35*). Ethanol distribution ratios between urine and capillary blood in controlled experiments and in apprehended drinking drivers were obtained using an enzymatic method (*36*). Skeletal muscle as well as blood and vitreous humor was analyzed for ethyl alcohol and the results were compared (*37*).

A method was developed using reversed-phase HPLC and refractive index detection using pure water as the mobile phase for the simultaneous determination of methanol, ethanol, and isopropyl alcohol (*38*). The postmortem determination of the biological distribution of formic acid from methanol intoxication has been performed by HSGC (*39*). Headspace capillary GC and ion trap mass spectrometry were used to detect volatile compounds in the blood of drunk drivers (*40*). The reasons behind the forensic GC determination of ethanol congener alcohols in human blood and urine have been reviewed (*41*), and the kinetics of aliphatic alcohols (methanol, propanol, isobutanol) in the presence of ethanol in humans has been reported (*42*). The presence of methanol in body fluids and tissues from a man who fatally ingested orally a large quantity of methanol was determined by HSGC (*43*). Acetaldehyde detection by GC in the blood of subjects who died of alcohol intoxication was studied (*44*). The highest blood concentration of acetaldehyde ever recorded was presented in toxicological findings of a case of fatal disulfiram–alcohol reaction due to ingestion of ethanol and Antabuse (*45*).

The interaction of ethanol with drugs has been discussed and reviewed (*46*). Using human cadavers, an experimental model was developed to simulate the agonal aspiration of drug- and alcohol-laden vomitus (*47*). A study has investigated the effect of ibuprofen on ethanol elimination rate and blood ethanol concentration using the Intoximeter 3000 and GC/MS (*48*). Bupropion and its metabolites were determined by GC with nitrogen–phosphorus detection (GC-NPD) and GC-MSD in several tissue and fluid samples from a victim of fatal ingestion of bupropion and ethanol (*49*). Forensic science aspects of ethanol metabolism have been reviewed (*50*), and a review on ethanol in forensic medicine has been published (*51*). Toxicological analyses and other forensic science data have been used to examine the mechanisms through which ethanol increased the risk for death caused by injected street preparations of heroin (*52*). The records of 248 female homicide and suicide victims admitted to the Salt River State Mortuary between January 1990 and July 1991 were reviewed with specific attention to the mode of death and BAC (*53*).

HSGC was used to determine the amount of carbon monoxide in heart and skeletal muscle (*54*) and in the spleen (*55*). The results of a multilaboratory check-sample analysis program for carbon monoxide and cyanide have been reported (*56*). The concentration of carboxyhemoglobin in the blood of subjects killed by CO poisoning (*57*) and by fires and burns was determined using colorimety (*58*). Correlations among age, concentrations of carboxyhemoglobin and hydrogen cyanide, oxygen density, and hemolysis were studied in 120 victims of house fires (*59*). The results of the analysis for carboxyhemoglobin and cyanide in blood from victims of the DuPont Plaza Hotel fire in Puerto Rico have been reported (*60*). A review of the recent literature on cyanide poisoning, mechanism of action, and analytical methods for cyanides has been reported (*61*). Cyanide in blood has been determined by headspace capillary GC using flame ionization detection (FID) (*62*) and election capture detection (ECD) (*63, 64*). Case results showing a high cyanide level in a homicide victim burned after death suggest that care should be taken to assess the value of elevated cyanide levels in a badly burnt fire victim (*65*). GC analysis of the gases in a manhole where two young boys died of asphyxiation determined that the concentration of oxygen was below the minimum required to maintain human life (*66*).

Volatile substance abuse, the clinical toxicology of volatile substances, the pharmacokinetics of volatile substances, and the diagnosis of poisoning by volatile substances have been reviewed (*67*). A simple method of screening for a wide range of volatile substances in biological fluids has been reported which used headspace capillary GC with split FID/ECD detection (*68*). Gas chromatographic retention indexes of volatile organic compounds of toxicological interest on Carbowax 20m/Carbopack have been reported (*69*). Aerosol

propellants in body fluids and tissues were detected by GC/MS (*70*). A general scheme for the synthesis and identification of alkyl nitrites has been presented which includes color tests, GC, infrared spectrophotometry (IR), and ultraviolet spectrophotometry (UV) (*71*). In a study which showed urinary *o*-cresol as a good indicator of toluene inhalation in glue sniffers, urinary *o*-cresol and expired air toluene concentrations were determined by GC, and urinary hippuric acid concentrations were determined by HPLC (*72*). A review of the literature, neuropharmacology, and pathophysiology of nitrous oxide and the autopsy findings from asphyxial deaths from the recreational use of nitrous oxide has been presented (*73*). *n*-Butane was detected by GC in the autopsy specimens from a butane gas abuser (*74*). Quantitative analysis of a propane explosion victim's blood, obtained during autopsy, was performed using GC/MS (*75*). The stability of toluene in blood and its forensic relevance was studied using GC and an ion-trap detector (ITD) (*76*). On reanalysis of body fluids from an autopsy by HSGC and GC/MS, the determination of acetonitrile was made, which had been mistakenly identified previously despite the use of two different GC column packing materials (*77*). A HSGC method for the quantitation of $CHCl_3$ in blood was developed (*78*). The identification of volatile hydrocarbons in biological materials has been reported (*79*) as well as the analysis for thinner components (*80*, *81*), kerosene and light oil (*82*, *83*), and ethylene glycol (*84–86*). A method for the headspace analysis of dimethyl sulfide in blood and adipose tissue has been reported which uses GC with flame photometric detection (FPD) (*87*). A simple method was developed for the detection and determination of chloral hydrate and diazepam by differential pulse polarography using potassium chloride in ethanol as a supporting electrolyte (*88*).

Cannabinoids. A protocol has been described that involves recording the morphological features of cannabis found in a sample and two thin-layer chromatography (TLC) systems for determining the cannabinoids present and that reduces the problems of the disposal of the hazardous waste produced with the use of the Duquenois–Levine test (*89*). Changes in the individual cannabinoid contents of hashish resulting from different storage conditions were determined by HPLC analysis (*90*). The identification and determination of cannabinoids in cannabis seeds has been accomplished by TLC and GC (*91*) and TLC, GC, and GC/MS (*92*). The tetrahydrocannabinol (THC) content of cannabis products seized by H. M. Customs and Excise on entry into Great Britian and Northern Ireland in 1984–1989 was determined by GC (*93*). (−)-Δ^9-*trans*-Tetrahydrocannabinolic acid A (THCA-A) was isolated from *Cannabis sativa* with a petroleum ether extraction and purified by medium-pressure liquid chromatography (*94*). Determination of cannabinoid acids by HPLC of their neutral derivatives formed by thermal decarboxylation has been reported (*95*). The cannabinoid acid pattern of plant preparations from *C. sativa* (hashish, marijuana) has been determined by a hexane extraction and by analysis of their methyl-TMS derivatives with high-resolution GC and GC/MS (*96*).

EMIT has been used for the detection of cannabinoids in urine (*97*) and in a methanolic extract of blood as a screening method in cases of suspected impairment by cannabis (*98*). The Syva EMIT d.a.u. cannabinoid 20 ng/mL assay was evaluated by comparing the data to Toxi-Lab and GC/MS (*99*). Abbott fluoresence polarization immunoassay (FPIA) and Roche radioimmunoassay (RIA) were compared for the analyses of cannabinoids in urine specimens (*100*). Results obtained from three commercial immunoassay kits, Abuscreen, TD_x, and EMIT, commonly used for the initial test of urine cannabinoids (and metabolites) were correlated with the 11-nor-Δ^9-tetrahydrocannabinol-9-carboxylic acid (9-THC-COOH) concentration as determined by GC/MS (*101*). Urine samples were analyzed by the EMIT d.a.u. cannabinoid 20 ng homogeneous enzyme immunoassay, the Diagnostics Product Corp. (DPC) cannabinoid RIA, two in-house cannabinoid RIAs, and a GC/MS method for 9-THC-COOH (*102*). Data from RIA screens and GC/MS quantitation of blood or blood and urine specimens for cannabinoids have been compared (*103*, *104*). Blood samples have been analyzed by GC/MS for THC, 11-0H THC, and 9-THC-COOH for the study and prediction of marijuana exposure and absorption times (*105*, *106*). Blood samples were analyzed for THC to examine the relationship between plasma levels and pharmacological effects of THC (*107*). Plasma levels of cannabidiol (CBD) have been determined by capillary GC/ion-trap MS (*108*). THC and 9-THC-COOH have been determined in the plasma using a single-quadrupole GC/MS operated in the negative chemical ionization mode and retrofitted with a High Energy Dynode detector system (*109*). The use of a hexadeuterated internal standard for the quantitation of 9-THC-COOH in urine by GC/MS has been reported (*110–112*). Solid-phase extraction has been used to extract 9-THC-COOH from human urine, and a number of techniques have been used for identification including GC/MS (*113–115*), GC (*116*), HPLC/UV (*117*), and micellar electrokinetic capillary chromatography (*118*). A report of an interference compound in the analysis of 9-THC-COOH by forming the dimethyl derivative and GC/MS has been cited (*119*). A liquid–liquid extraction procedure for the simultaneous detection of 9-THC-COOH and benzoylecgonine in urine has been described (*120*). Passive consumption of marijuana (THC) through milk has been investigated (*121*). THC, 9-THC-COOH, and its O-ester glucuronide were measured in plasma by GC/MS and in urine by GC/MS and EMIT (*122*). Blood samples from suspected drugged drivers who were clinically impaired and negative for alcohol were tested for drugs and THC (*123*).

Morphine and Related Narcotics. Samples taken from seizures of imported illicit heroin preparations of known geographical origin were examined (*124*). Analysis of illicit heroin and its impurities has been performed by GC/MS (*125*) and isotope-ratio MS (*126*), HPLC, (*127*, *128*), capillary GC-FID (*129*), and a combination of HSGC, GC/MS, TLC, HPLC, and atomic absorption (AA) spectrophotometry (*130*). Identification of meconine in heroin samples has been accomplished by using UV, MS, TLC, GC, and high-resolution GC (*131*). A method using a combination of HPLC-DAD and capillary GC-NPD has been developed for the rapid, sensitive and accurate analysis of illicit samples of heroin or cocaine (*132*). Mycocontamination of illicit samples of heroin and cocaine as an indicator of adulteration has been reported (*133*). Simultaneous determination of semisynthetic codeine base, α-codeimethine, and o^6-codeine methyl ether as byproduct impurities has been performed by HPLC (*134*). The densitometric determination of papaverine in opium, poppy capsules, and certain pharmaceutical dosage forms has been described using the rapid TLC scanning method (*135*). A fast, efficient reproducible method for the separation of the five major opium alkaloids by TLC coupled to flame ionization detection using the partial scanning or peak pyrolysis method is reported (*136*). In two recent cases, Hmong folk remedies, actually unknown solids resembling charcoal in consistency and purported to be "backache remedies", were analyzed by GC/MS and found to be complex mixtures of aspirin, acetaminophen, caffeine, and partly acetylated opium (*137*).

The Abbott AD_x fluoresence polarization immunoassay (FPIA) was compared to the HPLC-ECD results for total morphine concentraion of forensic human blood samples (*138*). Pentofluoropropionic anhydride (PFPA) and acetic anhydride derivatives of morphine and codeine were evaluated with respect to stability, chromatography, potential for analytical interferences by other opiates, and suitability of major fragment ions for analysis by GC/MS with deuterated internal standards and selected ion monitoring (SIM) (*139*). Morphine and 6-acetylmorphine were determined in plasma by HPLC with fluoresence detection after using solid-phase extraction (*140*). A method for the simultaneous quantification of codeine, ethylmorphine, and morphine in blood utilizing solid-phase extraction and GC/MS has been evaluated (*141*). The voltammetric behavior of morphine at a glassy carbon electrode and its determination in human serum by HPLC-ECD under basic conditions has been described (*142*). Morphine and hydromorphone have been determined in plasma using simultaneous solid-phase extraction and HPLC-ECD (*143*). Morphine and codeine have been determined in blood and bile by derivatization and GC-NPD or GC-ECD (*144*). Morphine and its glucuronide metabolites have been determined in human plasma using solid-phase extraction and HPLC-ECD (*145*) or HPLC-UV detection (*146*).

A totally automated procedure has been developed for the detection and quantitation of morphine and codeine in urine case samples utilizing the Syva ETS and a Zymate laboratory

robotic system (*147*). A series of articles on forensic drug testing for opiates have been written which have discussed the following: (1) the detection of 6-acetylmorphine in urine as an indicator of recent heroin exposure (*148*); (2) the metabolism and excretion rate of morphine in humans after morphine administration (*149*); (3) the urinary excretion rates of morphine and codeine following codeine administration (*150*); and (4) the analytical sensitivity, specificity, and accuracy of commercial urine opiate immunoassays (*151*). Morphine and other opiates have been identified in urine using solid-phase extraction and GC/MS (*152–154*), HPLC/atomospheric pressure ionization MS (HPLC/API-MS) (*155, 156*), HPLC-UV (*157*), and enzyme immunoassay (*158*). Morphine, codeine, and phencyclidine (PCP) were determined in urine by ion-trap mass spectrometry following solid-phase extraction (*159*). Morphine was determined in the vitreous humor of heroin overdose victims by GC/MS using reversed-phase solid–liquid extraction (*160*).

The possible contribution of poppy seed foods to positive opiate urinalysis results has been discussed and reported (*161, 162*). Heroin and 6-acetylmorphine have been identified in the hair of heroin users (*163*). Morphine and other opiates have been identified in hairs by ion-trap MS (*164*), and FPIA, EMIT, and GC/MS (*165*). The effect of washing upon the morphine content of hair has been investigated using radioimmunoassay (*166*).

Cocaine. Cocaine has been determined by an automatic continuous-flow atomic absorption method (*167*), derivative spectroscopy (*168*), and voltammetry (*169*). An ion-mobility spectrometer (IMS) has been developed and tested for use in the detection of trace amounts of cocaine and heroin in various customs scenarios (*170*). Low levels of cocaine were found in Mate de Coca tea brewed according to the label directions (*171*). Coca paste and several fractions from smoking products were analyzed by GC-FID and GC/MS (*172*). The inhalation efficiency and pyrolysis products of cocaine by the pyrolysis of crack and cocaine hydrochloride were studied by GC and GC/MS (*173*). Various approaches and analytical data have been reported concerning the differentiation and fingerprinting of cocaine samples (*174–178*). Cocaine and heroin samples have been characterized as a function of their trace element content by means of inductively coupled plasma atomic emmission spectroscopy (ICP-AES) (*179*). Truxillines in illicit cocaine have been identified by means of TLC and direct-probe mass spectrometry (*180*). Three previously unknown congeners in illicit cocaine have been isolated and identified by HPLC (*181*). Ethylbenzoylecgonine, a cocaine homolog, was identified by GC/MS in illicit cocaine that had been imported dissolved in liquor (*182*). *N*-Formylcocaine has been identified in illicit cocaine (*183, 184*). Injection-port-produced artifacts from cocaine base (crack) exhibits have been studied using GC/MS (*185*). Nuclear magnetic resonance (NMR) has been used to determine solvent residues in illicit cocaine exhibits (*186*).

Cocaine has been determined in serum, plasma, and blood by a GC-NPD method (*187*). Cocaine and benzoylecgonine were determined in whole blood and urine by means of a robotic solid-phase extraction and GC/MS (*188*). A combined assay has been described for cocaine, benzoylecgonine, and ecgonine methyl ester using reversed-phase HPLC with electrochemical and UV detection (*189*). Cocaine and cocaethylene were simultaneously determined in blood and tissues by GC-NPD and GC/ion-trap mass spectrometry (*190*). The role of ecgonine methyl ester in the interpretation of cocaine concentrations in postmortem blood has been discussed (*191*). The plasma from 10 human volunteers who received doses of cocaine by smoking, or intraveneously, was analyzed for cocaine and its metabolites (*192*). The serum and urine from 44 consecutive patients that tested positive for benzoylecgonine were examined for free cocaine, ecgonine methyl ester, and other metabolites by GC/ion-trap mass spectrometry (*193*). The collection and handling of clinical blood samples to assure accurate measurement of cocaine concentration was assessed by GC (*194*). A kinetic model of benzoylecgonine disposition after cocaine administration in humans has been described (*195*). A study of whether there is a change in the blood cocaine concentrations in the body during the postmortem interval has been reported (*196*).

Cocaine and its metabolites have been analyzed in urine by GC/MS (*197*), GC-NPD (*198*), HPLC using a column-switching technique (*199*), and HPTLC (*200*). Immunoassay methods for the screening of cocaine metabolites in urine have been evaluated (*201, 202*). A totally automated procedure has been developed for the detection and quantitation of cocaine and benzoylecogonine (*203, 204*). HPLC and GC/MS have been used in the certification of cocaine and benzoylecgonine in a human urine standard reference material (*205*). Urine specimens from males who injested Health Inca Tea were analyzed for benzoylecgonine by EMIT-d.a.u., TD_x, and GC/MS (*206*). Cocaine and its metabolites, including cocaethylene, were analyzed in urine using capillary GC-NPD (*207*).

A new solid-phase extraction procedure using high-flow copolymeric sorbents and HPLC has been used for the determination of cocaine and benzoylecgonine in amniotic fluid (*208*) and brain tissue (*209*). Cocaine and its metabolites have been detected in human amniotic fluid using FPIA (*210*). A comparison of the results obtained from assaying cocaine and its metabolites in biological fluids and organs from a fatal victim involving pure cocaine injection has been reported using the Abbott TD_x analyzer and GC/MS (*211*). A rapid method for the determination of cocaine and benzoylecgonine in brain tissue has been described which uses lipase digestion, solid-phase extraction, and HPLC (*212*). Cocaethylene and other cocaine metabolites have been determined in liver using HPLC with UV detection (*213*). FPIA and GC/MS was used in conjunction with solid-phase extraction to analyze the cocaine and benzoylecgonine concentrations in meconium (*214*). Cocaine and benzoylecgonine were determined in vitreous humor using HPLC with UV–visible photodiode assay detection and column switching (*215*). The presence of cocaine was detected by GC/MS in decomposed human remains from 77 medical examiner cases (*216*).

Hair analysis for drugs of abuse, specifically the facility in incorporation of cocaine and its metabolites into hair, has been studied (*217*). The analysis of cocaine in hair has been done by using GC/MS (*218–220*), GC/CIMS (*221*), RIA (*222*), and RIA and GC/MS (*223*). The use of hair analysis to document a cocaine overdose following sustained survival period before death has been reported (*224*).

Cocaine and benzoylecgonine have been determined in insect larvae found on a decomposed body (*225*). A brain specimen from an 18-week-old fetus was found to be positive for cocaine (*226*). Fetal concentrations of cocaine and benzoylecgonine were measured from infants who died at less than 2 days of age (*227*). Pathologic and toxicologic as well as birth developmental and social data have been presented from six cases of cocaine-related deaths of infants (*228*).

Amphetamines. Liquid chromatographic methods have been described for the analysis of forensic samples containing amphetamine and methamphetamine (*229*). Methods for the differentiation of methamphetamine from regioisomeric phenethylamines have been reported (*230*) as well as methods for the analysis for 1-(3,4-methylenedioxyphenyl)-2-butanamine and *N*-methyl-1-(3,4-methylenedioxyphenyl)-2-propanamine (MDMA) (*231*). Liquid chromatographic and mass spectral analysis has been reported for the 1-phenyl-3-butanamines (*232*) and 1-phenyl-2-butanamines (homologs of amphetamines) (*233*), 1-(3,4-dimethoxyphenyl)-2-propanamines (analogs of MDMA) (*234*), and 1-(3,4-methylenedioxyphenyl)-3-propanamines (regioisomers of MDMA) (*235*) and for the differentiation of 3,4-methylenedioxymethamphetamine (MDMA) from regioisomeric phenethylamines (*236*). GC/MS of *N*-methyl-1-aryl-2-propanamines synthesized from the substituted allylbenzenes present in sassafras oil has been described (*237*).

Amphetamines have been determined by HPLC with UV detection and on-line precolumn derivatization (*238*). A procedure for screening amphetamine-type drugs by a combination of normal- and reversed-phase TLC and visualization with Fast Black K salt was presented (*239*). The microcrystalloscopic differentiation of MDMA and related amphetamine derivatives has been described (*240*). Spot tests, IR spectrophotometry, MS, GC, and UV spectroscopy, and proton (^{1}H) and carbon-13 (^{13}C) NMR spectroscopy data have been presented for ephedrone (2-(methylamino)-1-phenylpropan-1-one) (*241*). GC, UV, IR, ^{1}H-NMR, ^{13}C-NMR, and MS data have been presented for 2,5-dimethoxy-4-ethoxyamphetamine (MEM) as well as its precursors (*242*). Differ-

entiation of side-chain isomers of ring-substituted amphetamines has been accomplished by GC/IR/MS (*243*). Chemical and physical properties of important precursors to the monoethoxy amphetamines, (*Z*)- and (*E*)-monoethoxy-1-(2-nitro-1-propenyl)benzenes, have been reported (*244–246*). FTIR/Raman differentiation and characterization of *cis* and *trans*-2,5-dimethoxy-4β-dimethyl-β-nitrostyrenes, precursors to the street drug STP, has been reported (*247*). A procedure has been described for the rapid characterization of methamphetamine enantiomers by ^{1}H-NMR analysis of diastersomers (*248*). An improved derivatization method for analyzing 12 ring- and N-substituted amphetamine derivatives in body fluids or seized materials has been described which uses GC/MS, GC-ECD, or GC-NPD (*249*). The synthesis and UV, IR, ^{1}H-NMR, ^{13}C-NMR, and GC/MS spectra have been reported for 4-ethoxyamphetamine and its isomers (*250*). A single analytical method for determination of optically active amphetamine and ethylamphetamine using (+)-α-methoxy(trifluoromethyl)phenylacetyl chloride (MTPA-Cl) has been developed (*251*).

The origin of alkenes in illicit amphetamine has been studied by GC/MS (*252*). An evaluation of the potential for clandestine manufacture of 3,4-methylenedioxyamphetamine (MDA) analogs and homologs has been presented (*253*). Differentiation of illicit phenyl-2-propanone synthesized from phenylacetic acid with acetic anhydride versus lead(II) acetate has been done using capillary GC/IR/MS and NMR (*254*). Lithium–ammonia reduction of ephedrine to methamphetamine was found to be a viable synthesis for methamphetamine (*255*). Samples from a clandestine laboratory involved in the synthesis of Ecstasy from sassafras oil were analyzed by GC/MS (*256*). Impurity profiles of methamphetamine were established to determine the origin of methamphetamine seizures by extracting samples with hexane under alkaline conditions and analyzing by GC (*257*). Micellar electrokinetic capillary chromatography of the enantiomers of amphetamine, methamphetamine, and their hydroxyphenethylamine precursors has been described (*258*). Samples of powder mixtures containing known quantities of methamphetmine hydrochloride and ephedrine hydrochloride were analyzed by multivariate analysis of X-ray diffraction data (*259*). The pyrolysis products of smoking methamphetamine mixed with tobacco were determined by GC and GC/MS methods (*260*). An investigation of the extraction of methamphetamine from chicken feed and other myths has been reported (*261*).

A review of amphetamine analogs has been reported (*262*). An investigation into the fact that β-phenethylamine causes false positive amphetamines in postmortem specimens when tested by Syva EMIT has been reported (*263*). A reversed-phase HPLC assay for MDMA and MDA in plasma has been described (*264*). A preliminary evaluation has been reported of the Abbott TD_x for screening of *d*-methamphetamine in whole blood specimens (*265*). A method for analysis of enantiomers of methamphetamine and amphetamine in urine with GC after derivatization was investigated (*266*). A procedure for eliminating interferences from ephedrine and related compounds in the GC/MS analysis of amphetamine and methamphetamine has been described (*267*). Methamphetamine and related compounds have been analyzed in urine by GC/MS (*268–275*), serial capillary GC/FTIR/MS (*276*), immunoassay and GC/MS (*277*), HPLC with chemiluminescence detection (*278–280*), headspace GC and GC/MS (*281, 282*), GC-ECD (*283*), GC-NPD (*284*), and surface-enhanced Raman spectrometry on colloidal silver (*285*). Immunoassays have been evaluated for the detection of amphetamines in urine (*286–288*). Amphetamines were determined indirectly by atomic absorption spectrometry (AAS) on the basis of their reaction with CS_2 to yield dithiocarbamic acids (*289*). Determination of amphetamines in hair has been studied by stable isotope dilution and GC/MS (*290–293*). Methamphetamine and its metabolite amphetamine were determined simultaneously in saliva by HPLC-ECD (*294*). The tissue distribution of MDMA in two cases of death involving MDMA were determined by GC-NPD, GC-MSD, and GC-FID using methylenedioxypropylamphetamine as the internal standard (*295*). Preliminary observations of the effect of methamphetamine in decomposing tissues on the development rate of *Parasarcophaga ruficornis* (Diptera: Sarcophagidae) and implications of this effect on the estimations of postmortem intervals have been reported (*296*). Schiff bases in putrified cadaver specimens have been identified by GC/MS (*297*). Analysis of amphetamines using 4-carboxyhexafluorobutyl derivatives and GC/MS has been described (*298*).

Barbiturates. Barbiturates were determined in human urine by full-screen GC/MS and solid-phase extraction (*299–301*). GC/FTIR was used for the qualitative detection of 10 barbiturates (*302*). A simple and reproducible method for the analysis of barbiturates by GC/MS after derivatization with DMF dipropyl acetal has been reported (*303*). Identification and differentiation of barbiturates and their metabolites in urine has been performed by computerized GC/MS (*304*). Enhanced UV detection of barbiturates in HPLC analysis by on-line photochemical reaction has been described (*305*). The analysis of barbiturates in human serum and urine by high-performance capillary electrophoresis electrokinetic capillary chromatography with on-column fast-scanning multiwavelength detection has been discussed (*306*).

Miscellaneous Drugs and Poisons. An analytical database has been presented for six benzodiazepines and benzophenones (*307*). Benzodiazepines have been detected in biological fluids using immunoassay techniques (*308–311*), capillary GC with a mega-bore column (*312*), solid-phase extraction and wide-bore capillary GC (*313*), GC/MS (*314*), immunoassay and GC-NPD (*315*), capillary GC-ECD (*316, 317*), direct-inlet electron impact mass spectometry (*318, 319*), solid-phase extraction and HPLC (*320*), HPLC (*321, 322*), capillary HPLC, and fast-atom-bombardment mass spectrometry (*323*), derivative UV spectroscopy (*324*), GC/FTIR (*325*), and quantitative liquid chromatography thermospray tandem mass spectrometry (*326*).

Four analogs of phencyclidine were synthesized and their UV, IR, ^{1}H-NMR, ^{13}C-NMR, and GC/MS spectra were published (*327*). Immunoassays have been evaluated for the detection of PCP in urine (*328–330*). Solid-phase extraction and capillary GC/MS has been used for the identification of PCP in urine (*331, 332*). The forensic distribution of methadone in biological fluids, tissue, and organs has been discussed (*333*). Methadone and its metabolites have been analyzed by GC/MS (*334*) and GC-NPD (*335*). A method for the HPLC analysis of methadone in plasma has been developed (*336*). FTIR spectroscopy with a microscope sampling device has been used for the identification of lysergic acid diethylamide (LSD) (*337*). LSD has been confirmed in urine by GC/tandem MS (*338*) and by RIA and GC/MS (*339*). A study of toxicology data, autopsy findings, and coroner's reports of 112 overdose deaths was reviewed to construct a profile of the typical fentanyl overdose victim (*340*). Samples analyzed by GC/MS revealed the presence of cis and trans isomers of 3-methylfentanyl (*341*).

Four selected case studies have been described to demonstrate the detection and identification of anabolic steroids in dosage forms as typically encountered in the forensic laboratory (*342*). IR and mass spectra of testosterone and 11 of its esters have been presented, and methods of analyzing preparations containing these anabolic steroids have been described (*343*). A TLC study of nine anabolic steroids has been carried out (*344*). Analysis of illegally distributed anabolic steroid products by reversed-phase liquid chromatography with identity confirmation by MS or IR spectrophotometry has been described (*345*). A study was designed to establish a method of analysis and identification of evidentiary cases of anabolic steroids which includes spot tests, FTIR, GC/MS, FT-NMR, and TLC (*346*). The prediction of GC relative retention times of anabolic steroids was performed by a quantitative structure–retention relationship (QSRR) and multiple linear regression analysis study (*347*). The illegal use of anabolic steroids and their control in Belgium has been discussed (*348*).

GC after solid-phase extraction has been used to determine meprobamate in serum or plasma (*349*). Analysis and isolation of indole alkaloids of fungi by HPLC has been reported (*350*). The concentrations of tricyclic antidepressants were determined by GC/MS with selected ion monitoring in a case of murder by strangulation (*351*). Propoxyphene, benzoylecgonine, and atropine were identified by capillay GC/MS (*352*). Liquid chromatographic and spectral (UV, FTIR, MS) analysis of stereoisomers of dimethylaminorex has been described (*353*). A case in which aminorex was prepared as a designer analog of a controlled substance, methylaminorex,

has been described (*354*). Skeletal muscle has been evaluated as an alternative specimen for alcohol and drug analysis (*355*). The important considerations in the interpretation of forensic urine drug test results have been discussed and reviewed (*356*). A kinetic study was undertaken, using a simple, rapid, and sensitive GC-ECD method to study chloral hydrate administration to neonates and the potential toxicological implications were discussed (*357*). A simple, rapid, inexpensive, and reliable color test to presumptively screen for the presence of ethchlorvynol has been described based on the reaction of ethchlorvynol and diphenylamine in the presence of acid (*358*). *d,l*-Ritalinic acid has been detected in plasma using an enantioselective GC-ECD assay (*359*).

Positive and negative ion mass spectrometry and rapid isolation by solid-phase extraction of 10 local anaesthetics has been described (*360*). Two commercial urine test strips based on the Greiss nitrite-specific diazonium salt reaction were evaluated for the rapid diagnosis of nitrite poisoning (*361*). A method for rapid detection and identification of bromvalerylurea, bromodiethylacetylurea, and allylisopropylacetylurea in serum and urine by HPLC and a multiwavelength UV detector after solid-phase extraction was reported (*362*). A solid-phase extraction method for rapid isolation and cleanup of some synthetic pyrethroid insecticides from human urine and plasma has been described (*363*). Construction of a paraquat-sensitive membrane electrode and its application to forensic chemistry has been described (*364*). Paraquat levels were determined by spectrophotometry in plasma, urine, and autopsy tissues from a suicide victim (*365*). The possibility that paraquat may be released from formalin-fixed tissues during the fixation process was investigated by ion-pair column chromatography (*366*). The tissue distribution and postmortem redistribution of Trazodone in two fatalities has been studied (*367*). GC was used to analyze the autopsy blood for trimipramine from a victim of fatal seizures (*368*). Cimetidine was determined in autopsy fluids and tissues by HPLC (*369*) and HPLC/MS (*370*). The forensic detection of salicylates by different color reactions, GC, TLC, and quantitative determination by UV spectrophotometry has been presented (*371*). Antitussive pholcodine was determined in human urine and hair by GC/MS, FPIA, and RIA (*372*). Interpretation of the postmortem blood concentrations of digoxin has been discussed (*373*). The toxicological screening method for drugs in gastric aspirates used by the Institute of Science and Forensic Medicine in Singapore has been described (*374*). GC/MS was employed to quantify endrin in biological fluids in a death attributed to endrin overdose (*375*). GC/MS was used to analyze blood and urine samples from a victim of fatal poisoning due to ingestion of cantharide powder used for aphrodisiac purposes (*376*). Propoxyphene was determined by GC in blood of victims of suicidal poisoning by Co-Proxamol (paracetamol and *d*-propoxyphene) (*377*). A rapid, simultaneous determination of paraquat and diquat in serum and urine using second-derivative spectroscopy has been described (*378*).

Chloroquine concentrations in blood and tissues were examined in overdose and nonoverdose cases to determine appropriate ranges for interpretation (*379*). A simple and rapid method for the isolation of eight triazine herbicides from human serum and urine, using solid-phase extraction and capillary GC, has been presented (*380*). A method was developed for the quantitative analysis of buflomedil in biological fluids from an acute intoxication victim using GC-MSD and extrelute extraction (*381*). Quantitation by GC-NPD and GC-FID of bupropion and its metabolites in the tissue of a fatal overdose victim has been reported (*382*). The use of radioreceptor assays for the determination of benzodiazepines in biological samples has been reviewed (*383*). Dilitiazem was determined by HPLC in the body fluids and tissues of a suicide victim (*384*). Isoniazid was extracted by a single-step extraction procedure, derivatized with trifluoroacetic anhydride, and identified and quantified by GC/MS (*385*). The toxicological and pathological findings of an apparent suicidal overdose of Clozaril have been presented (*386*). Postmortem blood samples and body organs from a fatal poisoning of copper sulfate were qualitatively analyzed by SEM microprobe analysis and X-ray fluoresence (XRF) and quantified by atomic absorption spectrometry (*387*). A simple and sensitive method to determine thiosulfate in human blood and urine using GC and GC/MS has been devised (*388*). Serum samples from a suicidal victim were analyzed for dilitiazem and metoclopramide by GC-NPD (*389*). Haloperidol was determined by GC-NPD and confirmed by GC-MSD *in postmortem tissue and fluids from two victims of* Haloperidol poisoning (*390*). Quantification of thiamylal was accomplished by HPLC and confirmation was done by GC/MS in postmortem tissue from a victim of fatal intravenous administration of thiamylal (*391*). Colchicine was identified by GC/MS of an organic extract of a urine specimen from a suicide victim (*392*). Tranylcypromine was determined by GC in blood, urine, and liver of two overdose victims (*393*). Acebutolol was identified in postmortem samples from a fatal case of self-poisoning by HPLC-DAD and liquid–liquid extraction (*394*). The simultaneous determination of bupremorphine and its major metabolite in urine samples has been studied by using reversed-phase HPLC-ECD and RIA (*395*). Carbofuran was detected in blood and gastric contents by TLC in a case of fatal ingestion of Furadan (carbofuran) (*396*). Arsenic was determined by AAS in samples from an acute suicidal arsenic intoxication (*397*). Triacetonetriperoxide (TATP), an explosive, was determined in a drug case by MS, IR, and UV spectrophotometry, energy-dispersive X-ray spectrometry, and GC (*398*). The clinical and morphological findings on mustard gas [bis(2-chloroethyl) sulfide] poisoning have been described (*399*). Baclofen was identified by GC/MS and HPLC in urine from a victim of Baclofen ingestion (*400*). The application of forensic toxicology to the problem of domestic violence has been discussed (*401*). The autopsy findings of a fatal acetaminophen poisoning case have been described (*402*). The usefulness of lung surfactant phospholipids in the diagnosis of drowning has been discussed (*403*). The creatinine concentration has been reported to be used to indicate possible adulteration of urine specimens by dilution as a means of avoiding detection of use of drugs of abuse (*404*). Thiamylal was quantified by HPLC/UV and confirmed by GC/MS in the blood of a suicide victim (*405*). Toxicological findings in military aircraft fatalities have been described (*406–408*). The toxicologic results from the 47 victims of the explosion on the USS *Iowa* were presented (*409*). A description has been given of the availability and quality of drugs seized in the Danish illicit drug market (*410, 411*). Cases of fatal poisonings among drug addicts and abusers of medical drugs from western Denmark has been discussed (*412*). Over 6000 youth, in grades 6–12 from rural communities in Canada, were surveyed for prevalence of licit and illicit drug (*413*).

General Procedures. The identification of drugs of abuse has been successfully achieved by using diffuse refectance FTIR spectroscopy (*414*), FTIR microscopy (*415, 416*); near-infrared spectroscopy (*417*), crystal microscopy and FTIR spectroscopy (*418*), on-line coupling of TLC and FTIR spectroscopy (*419*), NMR (*420*), ion mobility spectrometry (*421*), circular dichroism (*422*), chemiluminescence (*423*), and coupled chromatographic methods of GC/MS, GC/FTIR, and HPLC-DAD (*424*). The statistical approach to the representative sampling of drug seizures has been outlined (*425, 426*). The performance evaluation of an aqueous–organic phase separator for postcolumn reactions in HPLC, and its application to the enhanced detection of some basic drugs of abuse, has been described (*427*). A GC method for the quantitation of sugars in street drug samples has been reported (*428*). The influence of elution conditions on HPLC retention index values of selected acidic and basic drugs measured in the nitroalkane scale has been determined (*429*). It has been shown that a carefully selected drug mixture can be used to gain the interlaboratory reproducibility of retention indexes in capillary GC (*430*). The ADAPT software system was used to create models for the prediction of GC relative retention times of stimulants and narcotics (*431*).

Several reviews have been published discussing drug testing in the forensic toxicology laboratory (*432–435*). The history of forensic urine drug testing has been summarized and the current status of federal government-mandated testing and laboratory certification has been discussed (*436*). Analytical procedures that are performed in a state-of-the-art forensic laboratory have been discussed (*437*). Quality assurance requirements and assessments of a forensic toxicology laboratory have been reported (*438–440*). Four methods for testing impairment of driving due to drugs have been compared (*441*). The forensic science implications of site

and temporal influences on postmortem blood–drug concentrations have been studied (*442*). An optimized screening system for 170 pesticides based on TLC, GC, and UV spectroscopy has been presented (*444*).

A simple extraction procedure using aqueous ammonia has been extended to the analysis of a wide range of basic and neutral drugs in postmortem blood and other tissues (*445*). Solid-phase extraction procedures for the isolation of abused drugs from urine have been described (*446–448*). The application of Empore C-8 extraction disks for the screening of urine in the systematic toxicological analysis has been reported (*449*). Solid-phase extraction procedures for the isolation of abused drugs from blood have been described (*450, 451*). The merits of solid-phase extraction of drugs from biological tissues have been reviewed (*452*). A procedure for deproteinization of whole blood for drug screening using automatic pipetters has been described (*453*).

Several reviews have been published on the application of mass spectrometry and GC/MS in forensic toxicology (*454–457*). MS/MS techniques in forensic science have also been reviewed (*458*). Methods developed for the full-scanning GC/ion-trap MS analysis of the NIDA drugs of abuse in urine have been evaluated (*459*). An automated screening procedure using GC/MS for identification of drugs after their extraction from biological samples has been developed (*460*). The formation of formaldehyde adducts from various drugs by use of ethanol in a toxicological screening procedure with GC/MS has been reported (*461*). A rapid screening test for nine quaternary ammonium compounds in human urine by direct-inlet electron impact ionization mass spectrometry has been investigated (*462*). Mass spectra of several commonly abused drugs and their deuterated analogs were compared and evaluated with emphasis on the selection of suitable ions for selective ion monitoring when the isotopic analogs are used as the internal standards for a quantitative analysis (*463*).

Applications of GC in the forensic toxicology laboratory have been reviewed (*464*). Capillary GC has been used in the routine quantitative toxicological analyses (*465*). Packed GC-NPD has been used to measure blood, serum, and plasma drug concentrations of more than 40 basic drugs (*466*). A method consisting of single-step extraction, dual-channel capillary GC-NPD and automated data processing has been evaluated for the quantitative screening of acidic and neutral drugs in postmortem blood (*467*). Simultaneous determination of drugs by GC-NPD has been described (*468, 469*). The feasibility of using GC/FTIR for drug analysis in the forensic toxicology laboratory has been discussed (*470*).

Toxicological drug screening by TLC has been reviewed (*471*). The combined use of normal- and reversed-phase TLC in drug screening has been evaluated by the mean list length method (*472*). A numerical color coding system has been developed to describe the colors of spots obtained after using location reagents in TLC (*473*). The impact of high temperatures and moderate humidities on the applicability of TLC systems for drug identification in forensic toxicology has been studied (*474*). A rapid horizontal TLC method for detecting drugs of abuse in urine has been presented (*475*). The computer-aided optimization of liquid–solid systems in TLC for the analysis of drugs of abuse in forensic toxicology has been described (*476*). Instrumental planar chromatography has been applied to forensic toxicology (*477*). HPLC-DAD has been used in the forensic identification of drugs of abuse (*478–481*). The performance of a multiwavelength UV detector for automated drug identification following liquid chromatography has been evaluated (*482*). Solid-phase extraction and HPLC-UV confirmation of drugs of abuse in urine has been performed (*483*). HPLC correction procedures for toxicological analysis using the 1-nitroalkane retention index scale have been reviewed (*484*). Forensic application of coupling nonsuppressed ion exchange chromatography with ion exclusion chromatography has been presented (*485*).

Capillary supercritical fluid chromatography (SFC), packed-column SFC and capillary SFC/MS (*486*), and quantitative capillary SFC and supercritical fluid extraction (SFE) have been used in the analysis of drugs of abuse (*487*). The use of SFC for the analysis of compounds of interest in forensic toxicology has been described (*488*). Micellar electrokinetic capillary chromatography of drugs of abuse has been reported (*489–491*). Micellar liquid chromatography of drugs of abuse has also been reported (*492*).

Immunoassay procedures have been described for the detection of drugs of abuse in urine (*493–495*) and in blood (*496*). An absorption spectroscopic method has been applied to the sequential resolution of mixtures of pure components of toxicological interest which yield close UV absorption bands by using derivative spectroscopy (*497*). The use of a basic program for derivative wavelength determination calculations on a diode assay spectrophotometer with application to forensic databases has been reported (*498*). The detection of drugs of abuse in sweat (*499*) and in saliva (*500*) has been discussed. Drugs of abuse have been detected in hair by GC/MS (*501, 502*) and by immunoassay and GC/MS (*503*). Drug detection in hair by chromatographic procedures has been reviewed (*504*). Levels of some trace elements in selected autopsy organs, hair, and blood samples from adult subjects of the Italian population have been reported (*505*). References of network of experts, published resources, and experimental work in the forensic laboratory as sources of toxicological information have been reviewed (*506*). A computerized controlled substance inventory management in a forensic toxicology laboratory has been described (*507*).

FORENSIC BIOCHEMISTRY

A report of a collaborative exercise in DNA RFLP typing demonstrated the correlation of typing that can be achieved under conditions of minimal standardization (*508*). It has been shown that uniformity of DNA profile results can be achieved between different laboratories provided that a common protocol is used (*509*). The properties of DNA fingerprints detected by multilocus minisatellite probes 33.6 and 33.15 have been investigated (*510*). The use of multilocus minisatellite probe 33.15 has been described for forensic analysis (*511*). A collaborative study using the multilocus minisatellite DNA probe MZ1.3 was carried out to investigate segregation information, mutation rate, DNA fragment frequencies, and band-sharing characteristics (*512*).

Success rates for DNA typing in cases of sexual assault were high according to the experience of the Metropolitan Police Forensic Science Laboratory in London (*513*). The impact of environmental insults and contamination on the RFLP analysis of DNA in blood and other body fluid stains has been studied (*514*). The recovery and stability of DNA in samples of forensic significance has been reviewed (*515*). The effect of storage condition on RFLP analysis of DNA bound to positively charged nylon membranes has been studied (*516*). It has been demonstrated that high molecular weight DNA can be isolated using either organic or nonorganic DNA extraction protocols and that the resulting RFLP sizes are highly reproducible regardless of gel length, agarose type, or the presence or absence of eithidium bromide (*517*). Quantitation of DNA recovered from forensic case work material has been described (*518*). A method for the quantification of DNA based on probe hybridization to a human α-satellite has been described (*519*). Agarose gel electrophoresis of DNA in the presence of eithidium bromide has a marked effect on the mobility of genomic DNA fragments (*520*). A hybridization oven has been evaluated in connection with forensic DNA typing (*521*). Fixed bin analysis for statistical evaluation of DNA typing data has been described (*522*).

A comparative study between two laboratories on fragment-size frequencies detected by the probe YNH24 has been reported (*523*). The accuracy of procedures for sizing hypervariable restriction fragments was examined. In most cases, no significant deviation from the assumption of Gaussian distribution was noted (*524*). The sizes of DNA fragments on autoradiographs were measured by means of a computerized video scanner (*525*). The size of restriction fragment length has been determined by an image-processing system (*526*). A video-based scanning system has been developed for processing DNA autoradiographs (*527*). An image-processing system which will detect bands on a DNA autoradiographs has been described (*528*). A statistical analysis of the measurement errors in the determination of fragment length in DNA RFLP analysis has been reported (*529*). Measurement variation in the sizing of DNA fragments has been assessed, examining within-gel and between-gel

variability (*530*). A computerized system has been used to store DNA profiles from three hypervariable loci (*531*). The FBI is initiating a national computer database to enable the interchange of DNA typing information (*532*). The potential effectiveness of an international DNA database has been investigated (*533*). A common practice used in many analytical tests to show identity between two samples is to test the properties of the samples individually and mixed. However, this approach is not applicable to all forensic DNA tests (*534*). A guide to interpreting the evidential value of single-locus profiles of DNA mixtures has been presented (*535*). An assessment was made in evaluating how likely a close relative of a suspect can be responsible for a single-locus DNA profile (*536*). A simple but rigorous approach is offered for evaluating the evidential value of single-locus DNA autoradiographs (*537*). The probability of two individuals having the same DNA types has been examined (*538*). A simplified approach to calculating the Bayesian likelihood ratio for the case where two DNA single-locus profiles are to be compared has been described (*539*). A study has shown that DNA profiles can provide qualified indications about ethnic origin (*540*). It has been demonstrated that oligonucleotide probes with chemiluminescent tags can fully replace radioactive procedures in the forensic laboratory (*541*). DNA stripping procedures from a nylon membrane were evaluated (*542*). The FBI RFLP method for DNA typing has been described (*543*). Allele size distributions at loci D1S7, D7S21, D12S11, and D2S44 were determined (*544*). The complexity and stability of the D1Z2 region has been examined (*545*). Five methods of calculating frequency of occurrence of a DNA banding pattern have been compared (*546*). Simple algorithms have been compiled for estimating allele frequencies of hypervariable DNA systems (*547*).

Results show that DNA suitable for RFLP typing can be obtained from bone tissue (*548–550*). PCR analysis for DQ α has been conducted on DNA isolated from human bone (*551*). A study suggests that teeth provide an excellent source of DNA from sequencing mitochondrial DNA (*552*). Saliva and saliva-stained materials were examined as potential sources of DNA for DNA analysis. Both were found to be good sources of DNA (*553*). Environmental conditions examined did not affect the ability to obtain high molecular weight DNA from dental pulp (*554*). Bone DNA analysis was used to provide strong evidence that the remains exhumed from Brazil were those of Josef Mengele (*555*). Sexing of DNA studied from male and female blood can be accomplished through recognition of banding patterns, which depend on the restriction enzyme used (*556*). Areas of concern and confusion in evaluating DNA profiles have been reviewed (*557*). Issues related to the evaluation of DNA RFLP data were discussed (*558*). It has been demonstrated that evidentiary body fluids exposed to luminol, benzidine dissolved in ethanol, or phenolphthalein may still be successfully typed by RFLP procedures (*559*). Human trimeric and tetrameric short tandem repeats (STRs) were studied for suitability for DNA typing (*560*). DNA probes for elk, deer, and antelope have been developed by isolating highly repeated satellite sequences (*561*).

DNA typing of ribosomal ribonucleic acid (RNA) genes was performed with a PCR assay for species identification (*562*). Sex determination by PCR analysis of the X-Y homologous amelogenin gene has been reported to be highly reliable (*563, 564*). X and Y sequence amplification can provide a useful method for determining the sex of origin by PCR in DNA (*565*). Sex determination from bloodstains was accomplished by PCR of alphoid repeat sequences of the Y and X chromosomes (*566*). Fluorescent tagging of PCR amplified VNTR loci coupled with the laser detection of products during electrophoresis has automated DNA typing. The loci D1S80, D17S5, and ApoB were examined (*567*). An in vitro method for amplifying a large fraction of the DNA sequences present in a single haploid cell by repeated primer extensions using a mixture of 15-base random oligonucleotides has been developed (*568*). Part of the human mitochondrial D-loop DNA region has been amplified by PCR. A hypervanable segment of the D-loop region was readily sequenced in a single reaction (*569, 570*). DNA recovered from vaginal fluid was amplified by PCR with D1S80 primers (*571*). Total inhibition of PCR amplification and/or dropout was observed at D17S30 and the ApoB gene by some vaginal microflora (*572*). Allele and genotype frequencies for the D1S80 locus were determined by PCR and high-resolution electrophoresis (*573, 574*). PCR followed by SDS–PAGE in miniaturized nondenaturing gels was successfully used to type DQ α and the VNTR recognized with the probe D1S80 (*575*). A procedure for the amplification by PCR of the VNTR loci D1S80 and D17S30 and the ApoB gene is presented (*576*). A hypervariable region has been described 3′ to the human ApoB gene. Using PCR and gel electrophoresis, at least 16 different alleles can be distinguished (*577*). Use of PCR DQ α-typing in casework has been described. The technique has been found to be very applicable to criminal investigation (*578*). Application of formamide in the amplification of DQ α sequences by PCR is discussed (*579*). A PCR DQ α-typing kit has been evaluated by five crime laboratories. All samples with two exceptions were correctly typed (*580*). The results of validation experiments indicate that typing of the DQ α-gene by PCR can be accomplished without producing false positive or false negative results (*581*). PCR-based techniques can provide a means of typing DNA derived from the soft tissue of fire victims. All samples tested could be typed by DQ α and amplification of the D1S80 locus (*582*). DQ α may be typed by using a reverse dot–blot procedure or alternatively by restriction mapping. The latter has been shown to be a rapid and sensitive method though neither of these methods is entirely ideal. They are highly complementary to one another (*583*). A PCR amplification system for the DQ α-locus has been developed that will allow the presence of individual alleles in a sample with mixed genotypes to be determined (*584*). Allele frequencies for the northern Italian population are reported for DQ α (*585*). DNA typing of bloodstains has been carried out by PCR amplification of DQ α and DQ β (*586*). To increase the sensitivity of forensic stain analysis, the PCR reaction techniques were used to amplify a hypervariable from HLA-DRB genes (*587*). A rapid and sensitive typing of dried stains by PCR amplification in the HLA-DRB gene region and three novel tetranucleotide polymorphisms located autosomally, as well as on the human Y chromosome, has been accomplished (*588*). PCR in combination with RFLP was used for HLA-DPB1 typing (*589*). A rapid and sensitive method for ABO blood grouping by PCR has been developed (*590*). A simple approach to DNA typing has been developed that displays patterns of variant repeat units along minisatellite alleles using PCR amplification (*591*). Minisatellite variant repeat mapping by PCR has been applied to the hypervariable human minisatellite D1S8 (*592*). PCR technology in forensic science has been reviewed (*593–598*). DNA typing has been reviewed (*599–604*).

A comparative study of the sensitivity and specificity of presumptive blood tests was undertaken. The author concludes that the phenolphthalein test is the best single test for evaluating suspected bloodstains (*605*). Results indicate that luminol does not affect additional presumptive chemical tests, confirmatory tests, species determination, or ABO typing, but does affect certain genetic marker systems (*606*). A combination of absorption–elution and two-dimensional absorption–inhibition procedure was used to determine the ABH antigen composition of a series of human bones. The combination method was found to be a highly reliable procedure for bone tissue ABH typing (*607*). A and B antigens in bloodstains were detected by using A and B antibodies immobilized on nitrocellulose membrane strips (*608*). ABO grouping of blood was accomplished by absorption–elution using nitrocellulose beads as immunoabsorbents (*609*). The ABH antigens of bloodstains were detected on a nitrocellulose membrane by ELISA (*610*). Plenimetric immunoassay methods for the Lewis blood grouping of bloodstains have been demonstrated (*611*). Some polymorphic proteins and enzymes were determined in bloodstains by isoelectric focusing with carrier ampholytes and with immobilized pH gradients (*612*). Bloodstains present on articles of silver may have their phosphoglucomutase (PGM) isoenzymes markedly affected (*613*). Transferrin (Tf) subtyping was carried out on bloodstains. All three Tf common types and two rare types found in semen samples correlated with the type found in the corresponding blood sample (*614*). Erythrocyte acid phosphatase (EAP) and esterase D (EsD) were determined in bloodstains (*615*). A study has demonstrated that mixtures of EAP and PGM can lead to misinterpretation of blood grouping results (*616*). Blood group frequencies for ABO,

PGM, EAP, and glyoxylase 1 (GLO) are presented for the West Indian populations (*617*). The phenotypic distribution of the polymorphic enzyme α-L-fucosidase has been studied in the New York City population (*618*). Haptoglobin phenotype have been determined from older bloodstains. Haptoglobin (Hp) frequencies were calculated (*619*). An immunoblotting method for phenotyping Hp in serum and bloodstains has been developed (*620*). Hp phenotypes from minute quantities of tissue sample were determined after extraction with nonionic detergents (*621*). Hp typing has been conducted on dog blood samples (*622*). Hp has been detected in concentrated urine samples by enzyme immunoassay (*623*). The pair of isoenzymes Bf and Bs encoded by an allele of human red cell acid phosphatase has been sequenced (*624*). Laboratory methods for the determination of various forms of hemoglobin have been reviewed (*625*). Immunofixation procedures were used for detection of α-1-antitrypsin (Pi) in bloodstains (*626*). A simple rapid method for the simultaneous determination of coagulation factor X111A and plasminogen phenotypes by isoelectric focusing has been reported (*627*). Pregnancy hormones have been detected in bloodstains by radioimmunoassay techniques (*628*). P-30 has been used to sex discriminate blood and bloodstains (*629*). The survivability of albumin and IgG in bloodstains on fragments of cloth burned in soil was examined (*630*). By using HPLC, an unidentified marker in human bloodstains was found useful for estimating the age of a bloodstain (*631*). Aged red blood cells have been examined by scanning electron microscopy (SEM) for their morphology characteristics (*632*). A scheme is offered for the calculation of blood group frequencies for mixed racial populations. The scheme relies on the assumption of independence between different genetic markers with a randomly mating population (*633*). The interpretation of serological typing data as a problem of forensic science, as opposed to a problem in population genetics or statistics, has been considered (*634*).

A high-intensity light source was successfully used for the rapid detection of semen stains (*635*). A more sensitive modification of the zinc test for semen has been developed which can be used either as a solution or incorporated into test papers (*636*). The modified zinc test and a commercially available acid phosphatase test were compared as to their screening parameters according to the microscopical finding of spermatozoa in cases of alleged sexual assault. The zinc test was found to have a higher sensitivity and higher predictive values than the acid phosphatase test (*637*). A method for proving the presence of semen has been established by utilizing the chemiluminescence of choline (*638*). A monoclonal antibody was used for the development of a rapid method for the detection of human seminal plasma (*639*). An ELISA method for determining the ABO type and secretor states of body fluids and stains other than blood has been described (*640*). The isoenzyme deoxyribonulease I has been typed in liquid semen. This enzyme could provide an additional discriminant characteristic in the forensic examination of semen (*641*). A correlation between testosterone and dihydrotestosterone exists in seminal plasma. This ratio has been shown to be useful for the individualization of human semen (*642*). An isoelectric focusing method for typing Tf from semen stains has been reported (*643*). A survey on cases involving oral sex was reported by the Metropolitan Police Forensic Science Laboratory (*644*). Saliva stains were differentiated from various other stains by the high specific activity of amylase (*645*). Bone marrow and dental pulp from dead bodies were analyzed for genetic markers PGM, GLO-I, adenosine deaminase (ADA), EsD, and EAP (*646*). Genetic markers found in human bone tissue have been described (*647*). ABO blood groups were determined in tooth materials using the absorption–elution method (*648*).

TRACE EVIDENCE

Petroleum Products. Examples are presented to illustrate how GC/MS can be used to make conclusive determinations in situations where conventional GC may not be sufficient for the detection of hydrocarbon residues recovered from fires (*649*). Selected ion chromatograms can be used to characterize accelerants present in fire debris (*650*). A GC/MS method was developed for the analysis and identification of selected petroleum-related target compounds in highly contaminated extracts of fire debris (*651*). A GC/MS system specifically geared toward the detection of petroleum-based volatiles in suspect arson samples has been devised (*652*). Various techniques used to separate accelerants from fire debris samples before instrumental analysis is undertaken have been reviewed (*653, 654*). Procedures for trapping volatile accelerant vapors in the headspace of a closed container are described. These procedures trap the accelerant vapors onto charcoal which is either encased in a porous pouch or impregnated into a flexible membrane (*655*). The difference between manufactured turpentine and the material products of many soft woods found in fire debris cannot be established with scientific certainty (*656*). The effects of selective microbial activity on hydrocarbon accelerants have been examined both in vitro and in simulated arson residues. Microbial action on accelerants is of importance to arson investigation (*657*). A polyester–polyolefin bag was shown to be free of contaminants and sufficiently retentive for packaging arson evidence (*658*). Doubt has been cast on the theories that gasoline or volatile petroleum liquid fuels used as accelerants can cause explosive spilling on concrete slabs (*659*). Mathematical simulation of the weathering of gasoline has been reported using GC retention data (*660*).

Explosives. Microscopy, SEM/EDX, and spot tests were used to detect and identify match head residues in postexplosion debris (*661*). Capillary electrophoresis has been shown to be a useful tool in the analysis of low-explosive residues (*662*). The applications of GC/MS and MS/MS to the forensic identification of explosives has been reviewed (*663*). Ion chromatography of low explosives has been described. It has been shown that swabs from metal surfaces are of value in establishing the nature of the explosive charge used provided they are located within a short distance of the explosion site (*664*). Methenamine has been found as a chemical component in an improvised incendiary device. Methenamine will support combustion and was probably included as a fuel to keep the fire burning longer (*665*). GC analysis with a nitro/nitroso-specific detection in combination with solid-phase extraction has been found to be a useful technique for detecting low levels of explosive residues (*666*). The reaction mechanism which produces the violent reaction between calcium hypochlorite and brake fluid has been explored (*667*). Analysis of an explosive material triacetone triperoxide has been reported (*668*). Experiments indicate that wood and painted material exposed to trinitrotoluene (TNT) vapor absorb TNT and then desorb the TNT into the air for several days after removal of the source (*669*). The analysis and characterization of TNT by HPLC has been described (*670*). Trace amounts of explosive compounds may be trapped from HPLC effluents onto a porous polymer microcolumn for confirmatory GC examination (*671*). An enzyme-linked immuosorbent assay (ELISA) has been developed for the detection of TNT residues on hands. As little as 50 pg of TNT can be detected (*672*). The detection and identification of explosive residues has been reviewed (*673*).

Gunpowder and Primer Residue Detection. Three gunshot residue (GSR) collection methods from hand samples by SEM/EDX were compared. A table of advantages and disadvantages of each technique was developed (*674*). Automation of gunshot residue analysis by functional interpretation of an SEM/EDX system has been described (*675*). The effects of parameters such as particle size, video threshold, and X-ray counting time on automated analysis of a GSR sample by SEM have been described (*676*). The probability of finding GSR particles when only a portion of a specimen is to be searched has been calculated (*677*). SEM/EDX analysis has been used to characterize primer discharge particles emitted by exploding hand grenades (*678*). A collection device for the sampling of gunshot residue particles from clothing has been reported (*679*). Flakes of smokeless powder collected from clothing around bullet holes were analyzed by GC and HPLC. Propellants from different manufacturers were distinguishable (*680*). When ammunition that has mercury fulminate-based primers is fired, a much lower percentage of mercury containing GSR particles is found in samples taken from the shooter as compared to the percentage of such particles in samples from cartridge cases (*681*). Surface analysis and surface measuring techniques in firearm offenses are reviewed (*682*). Two different methodologies have been proposed to estimate firing distances

with the aid of GSR deposited around a bullet hole (*683*). Nitrite ions and metal present in gunshot residue swabs recovered from hands of a firer have been successfully detected by differential pulse voltammetry (*684*). Micellar electrokinetic capillary electrophoresis provides rapid and efficient separation and detection of organic gunshot residue constituents (*685, 686*). Case studies have shown that "mixed" GSR compositions can easily be formed. It is therefore possible to find discharge particles that differ in composition from those of the ammunition fired (*687*). A review deals with scientific methods for determining shooting distance. In addition, a survey is given on the chemical element found in GSR (*688*).

Paint and Glass. Sections of colored household paint were examined microscopically to discern the size and color of pigment particles (*689*). Alkyd resins have been analyzed and characterized by pyrolysis GC (*690*). The usefulness of pyrolysis GC has been demonstrated by the analysis of paints and other trace evidence (*691*). General spectroscopic processes associated with the use of FTIR microscopy used to examine paint samples are described (*692*). The results of Canadian vehicle color surveys have been presented (*693*). A method is described for removing paint smears from tools and clothing. The smear can be lifted with adhesive tape or epoxy resin and subsequently embedded in an epoxy resin if required (*694*). A modified method for producing sections of paint from fragments has been described (*695*). The mechanism of spraying with unshaken paint cans was studied using X-ray radiography. It was found that large variations in the characteristics of sprayed paint coatings can be obtained, depending on whether the cans were shaken before the spray was applied (*696*). A review of analytical techniques used in forensic paint comparisons has been undertaken (*697*).

The elemental composition of tempered sheet glass was determined by X-ray fluorescence and inductively coupled plasma atomic spectrometry (*698*). Inductively coupled plasma mass spectrometry was used for the characterization of window glass fragments having identical refractive indexes. Tests performed produced successful discrimination levels in the range of 85–90% (*699*). Neutron activation analysis has been used for the discrimination of flat glass fragments. High levels of discrimination were attained. Float glasses were also readily distinguished by their aluminum levels (*700*). The effect of changing the dimensions of window panes on the distribution of glass particles when they were smashed has been investigated. No significant trends were identified (*701*). Following the breaking of window glass, many of the background flying fragments bear some of the original window surface. The proportions of front, bulk, and rear surface particles are highly variable (*702*). A computer program has been devised for deciding how many recovered items of glass to compare to a control sample (*703*). A study was undertaken to determine the size and distribution of glass fragments, as well as the relationship that exists between finding glass fragments originating from the back surface, the front surface, and the core of the windowpane (*704*). An experimental devise for the systematic breaking of window glass was constructed. Relationships were demonstrated in the manner in which fragments are scattered according to size (*705*). Clothing was examined for the presence of glass fragments. The effect of grouping refractive index data into sources of glass was examined (*706*). A finding of crazed glass in a fire scene has no special meaning regarding the temperatures at which the glass was exposed (*707*).

Hairs and Fibers. DNA typing of DQ α by PCR from single hairs could be determined from single plucked hair roots. However, it was not easy to type hair shaft portions (*708*). DNA was extracted from human hair roots. RFLP analysis was successfully carried out. However, because of methodology difficulties this profiling should only be done with several hair roots (*709*). Hair was typed for PGM, EsD, EAP, GLO-I, and PGM. Satisfactory results were obtained for all the enzymes, even when samples were stored at room temperature up to 18 days (*710*). Hair protein variations based on genetic or acquired origin are reviewed with special reference to forensic hair comparison (*711*). Thirty-one different mountants were evaluated for the forensic examination of hair (*712*). A statistical evaluation of the evidential value of human hair has been derived (*713*). The source of blue discoloration found microscopically in human head hair roots was investigated and found to have possibly come from blue dye added to methadone (*714*). Components of hair sprays were detectable on hairs by GC as long as 24 h after treatment (*715*). GC/MS analysis of hair dyes was undertaken. The presence and relative amounts of dye components from hair extracts may assist in the discrimination of human hair (*716*). An isoelectric focusing technique for human hair keratins has been developed. The method described can be applied to the forensic analysis of a single human hair (*717*). Tunnels produced in human head hair by fungi were examined with a light microscope and with an SEM (*718*).

The effectiveness of the recovery of fibers by taping has been investigated using three types of fibers. The main parameters affecting the efficiency of recovery appear to be the type of recipient surface and the type of transferred fiber (*719*). A procedure is described for recovering fiber evidence using an adhesive lift (*720*). A membrane filtration system under vacuum has been used to concentrate fibers removed from tape by dissolving the tape adhesive in a solvent (*721*). A single scheme is described for the extraction and classification of dye stuffs from cotton and viscose fibers (*722*). Fiber dyes extracted from single fibers were analyzed by HPLC (*723*). Dyes extracted from single fibers were analyzed by HPLC/MS (*724*). DRIFT spectra were collected from dye mixtures extracted from textile sample (*725*). A simple sequential scheme to classify cotton dyes based on their degree of extraction has been described (*726*). Acetate fibers can be discriminated by solvent and melting point determinations (*727*). On the basis of pyrolysis GC variations, acrylic fibers were subclassified into nine groups and the modacrylics into six groups (*728*). Microspectrofluorometry has been shown to be a valuable technique for the discrimination of textile fibers. It appears to be particularly applicable with fluorescent brighteners (*729*). A system has been described which permits an analyst to systematically code fluorescence emission colors (*730*). Microspectrofluorometry has been used to examine the decay in emission intensity of a range of fluorescent materials. Fluorescence decay phenomena were shown to be of little use in the discrimination of single fibers (*731*). Glass calibrant slides have been used to standardize a number of microspectrophotometers. Ultimately, this permits the interchange of color measurements of fiber made at different laboratories (*732*). FTIR analysis was shown to be a forensic discrimination tool of single textile fibers (*733*). The role of the IR microspectrophotometry in forensic fiber analysis has been described in detail. IR microscopy is useful for identifying the chemical subclass of a fiber (*734*). IR spectra of fibers were obtained using a specifically designed anvil and template to preflatten the fiber (*735*). A spectral database for the identification of single fibers by IR microscopy is presented (*736*). Methods of tracing fiber manufacturers have been described (*737*). A listing of new fibers produced during the past decade is provided (*738*). The application of Bayes' theorem to the interpretation of fiber transfer evidence is discussed (*739*). A method was developed to determine the fiber shielding ability of various fabrics. Experimental conditions were more reproducible then the use of adhesive tape (*740*). Polyester fibers were classified by manufacture using HPLC and a multivariate pattern recognition technique (*741*). An investigation was carried out on the influence of fabric softener of fiber transfers (*742*).

Fingerprints. Fine flake powders were produced to study their effectiveness in detecting latent fingerprints (*743*). Several factors which can influence the extent to which latent fingerprints can be obliterated by powder development have been explored (*744*). New magnetic flake powders have been produced for developing latent fingerprinting (*745*). Four hitherto unknown amino derivatives of ninhydrin have been prepared and examined as potential fingerprint reagents. All developed fingerprints on paper in a manner similar to ninhydrin (*746*). Ninhydrin derivatives bearing sulfur-containing groups exhibit excellent properties as fluorogenic fingerprint reagents on paper (*747*). 1,8-Diazafluoren-9-one (DFO) has been used as a post-ninhydrin procedure in developing latent fingerprints (*748*). DFO mixed with petroleum ether and xylene is very effective for developing latent prints on paper (*749*). Stains and dyes have been tested on cyanoacrylate-developed fingerprints using an alternate light source. The fluorescence of the fingerprints has been examined (*750*). Androx staining is an effective latent print-

developing technique (*751*). Ardrox staining has been shown to be successfully used with cyanoacrylate fuming for visualizing latent fingerprints (*752*). A modified ruthenium tetraoxide procedure has been developed to develop latent fingerprints (*753*). Vacuum metal deposition has been shown to be superior to cyanoacrylate ester fuming on low-density polyethylene substrates (*754*). A microspectrophotometer fitted with a laser or a filtered light source was used to determine the fluorescence emission spectra and thereby improve the contrast between fingerprints and their backgrounds (*755*). A laser system that permits detection of latent fingerprints under high background light is described (*756*). 3,3′-Diaminobenzidine (DAB) has been found to be applicable to visualizing ridge details in blood (*757*). Fingerprints on a variety of common substrates can be stained with biological stains or select fabric dyes to enhance their contrast (*758*). Images of fluorescently tagged latent fingerprints were obtained using a charge-coupled devise detector (*759*). Latent fingerprints have been developed with dry photostatic toners (*760*). The use of liquid crystal detectors for studying fingerprint images has been investigated (*761*). A review of the reported methods for the recovery of fingerprints from the skin is presented (*762–763*). Latent fingerprints on skin or other difficult surfaces were developed by cyanoacrylate fuming utilizing a treated neutral filter paper (*764*). Poly(ethylene terephthalate) sheets coated with printing ink were used to visualize impressions of fingerprints on skin (*765*).

Miscellaneous. Procedural steps taken during the forensic examination of soils are described (*766*). Soil comparisons have been carried out by HPLC on the basis of chromatographic profiles, ratiograms, and absorbance ratio values of prominent peaks (*767*). A microhole punch was devised, allowing for the rapid collection of paper plugs from inked documents (*768*). It has been shown that transmission spectra of small samples of inked paper fibers smeared on glass slides resemble spectra of smeared ink deposits and are more reproducible than spectra of inked fibers in a mounting medium (*769*). HPLC systems were developed for the examination of blue non-ball pen inks. Over 100 inks were distinguished (*770*). Diffuse reflectance (DR) with FTIR spectrometry has been found to provide useful information for the characterization of ball-point pen inks. DR analysis combined with TLC provides enhanced value to the forensic examination of inks (*771*). The applicability of FTIR microsampling techniques to the nondestructive analysis of ball-point pen inks on questioned documents has been discussed (*772*). Fiber tip pens were differentiated by TLC (*773*). Capillary zone electrophoresis has been applied to the analysis of water-soluble fiber-tip pen inks from documents (*774*). An examination of 56 inks with an argon ion laser revealed that laser-induced IR luminescence may be a useful tool in differentiating inks (*775*). Colored pencils have been differentiated by TLC (*776*). The use of chromatography for the separation and comparison of ink components has been reviewed (*777*). Different brands of computer printer ribbons have been differentiated by TLC (*778*). Techniques used to detect fraudulent documents have been reviewed (*779*). A review of past and current practices for ink dating on documents has been published (*780*).

The chemical and physical properties of photocopy toner have been reviewed. The analysis of toners removed from copy papers has been described (*781*). A combination of DR and pyrolysis GC has been used for analyzing photocopying toners and adhesives on questioned documents (*782*). DR analysis makes possible the differentiation of photocopying toner samples obtained from different photocopying machines (*783, 784*). A case is described where red lycopodium powder was used to reveal an attempt at erasure (*785*). Lycopodium has been used to detect dry-transfer lettering on documents (*786*). Mass spectrometry has been used to characterize pigments present on counterfeit money (*787*). Two-dimensional HPLC has been used to analyze plastic fragments of automobile lenses (*788*). Analytical methods for the identification of lubricants have been described (*789*). Forensic characteristics of black shoe polish have been evaluated and used to analyze polish on clothing (*790*).

Microspectrophotometry offers a rapid and objective means of discriminating minute amounts of lipstick smears. Particle analysis by SEM/EDX can distinguish between lipstick stains on the basis of elemental composition (*791*). Forensic examination of bulb filaments by SEM has been reviewed (*792*). Temperatures of the off-filament adjacent to the incandescent filament in a double-beam headlight were measured (*793*). Trace quantities of physical evidence have been rubbed onto an abrasive silicon carbide disk and then analyzed by DR. The technique has been successfully applied to the analysis of paint, rubber, cosmetics, correction fluid, and adhesives (*794*). An automated thermal desorption GC technique has been adopted to analyze traces of volatile compounds in faced wrapping films (*795*). Different layers in multilayer polymer films were characterized by combined optical microscopy IR microscopy and computerized spectra manipulation techniques (*796*). Nail polishes have been discriminated using X-ray fluorescence (*797*). The use of neutron activation analysis for the direct comparison of trace elements in lead shot has been reported (*798*). A silicone/magnetic powder technique has been successfully used for obtaining test prints of footwear and tires (*799*). Procedures for the examination of paper matches have been reviewed (*800*). Case examples serve to illustrate the value of trace evidence in accident investigations (*801*). A review of forensic microscopy is offered (*802*). Applications of pyrolysis GC to the analysis of forensic evidence have been reviewed (*803*). Forensic applications of IR microscopy have been reviewed (*804*). Mass spectrometry applications in forensic sciencehave been reviewed (*805*). The choice of survey data in evaluating forensic evidence is discussed (*806*).

BOOKS

There has been some noteworthy books published on forensic science topics since 1990. *Forensic Examination of Fibers* (*807*) is required reading for the examiner of trace physical evidence. *The Use of Statistics in Forensic Science* (*808*) provides valuable insights into methods for assessing the evidential value of physical evidence. *Gas Chromatography in Forensic Science* (*809*) describes the application of GC to various aspects of forensic chemistry. *DNA Profiling: Principles, Pitfalls and Potential* (*810*) and *Proceedings from the Second International Symposium on Human Identification* (*811*) are excellent sources of the latest techniques being applied to DNA typing. The legal and scientific issues of DNA typing technology has been thoroughly described in *DNA Technology in Forensic Science* (*812*). The proceedings of an FBI-sponsored symposium on DNA typing techniques are contained within *Proceedings of the International Symposium on the Forensic Aspects of DNA Analysis* (*813*). Scientific, legal, and ethical issues related to forensic DNA typing are discussed in *DNA On Trial: Genetic Identification and Criminal Justice* (*814*). Murray and Tedrow have revised their excellent book on *Forensic Geology* (*815*). An excellent treatment of modern fingerprint techniques can be found in *Advances in Fingerprint Technology* (*816*). Barry Fisher has again revised the classic textbook *Techniques of Crime Scene Investigation* (*817*). *The Pathology of Drug Abuse* (*818*) is a comprehensive reference volume discussing stimulant, opiate, and steroid abuse. Sunshine's *1991 Year Book of Toxicology* (*819*) and *1992 Year Book of Toxicology* (*820*) review important published research papers in forensic toxicology. A complete, self-contained collection of drug-related spectral data is to be found in the five-volume set of *Instrumental Data for Drug Analysis* (*821*). *The Analysis of Drugs of Abuse* (*822*) contains both review and research articles relevant to the topic of illicit drug analysis. *Forensic Science Progress, Vol. 5* (*823*) and *Forensic Science Progress ,Vol. 6* (*824*) contain relevant review chapters on topics of forensic interest.

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