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Review Contents

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 1993 through December 1994. 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, trace evidence, and forensic biochemistry. 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. Quality assurance in breath alcohol analysis has been reviewed (*1*). A study of the precision of an experimental dual-system breath analyzer which measures the alcohol content of exhaled air both by infrared (IR) absorption measurements at 9.4 μm and with a fuel cell has been reported (*2*). A method has been described for the detection of interfering gases such as solvents during the forensic determination of blood alcohol levels with breath alcohol analyzers (*3*). A case has been presented where the breath alcohol concentration may not reflect the concentration of alcohol in blood (*4*). An Intoxilyzer 4011A was used to measure breath alcohol concentration to assess the effect of food on alcohol absorption and elimination patterns (*5*). A gas-phase biosensor has been evaluated for the measurement of gaseous ethanol (*6*). Solvents normally encountered in glue-sniffing cases have been shown to interfere with the breath alcohol Alcomat IR absorption-based instrument (*7*). A retrospective study of duplicate breath samples from BAC Verifier Data Master instruments was evaluated for the frequency of interference by acetone (*8*). A case has been reported where isopropanol interfered with the BAC measured on two different BAC Verifier Data Master infrared breath alcohol instruments (*9*). Comments on the breath acetaldehyde concentrations and the measurement in body fluids have been reported (*10*). The inhalation of gasoline vapors resulted in a falsification of breath alcohol levels as evaluated with the Alcomat IR breath-analyzer measuring absorbances at 3.4 μm (*11*). Sulfuric acid was combined with potassium dichromate in a large, demonstration-size, test tube to illustrate to students the reaction involved in the breathalyzer (*12*).

The effect of different columns and internal standards on the quality assurance of the gas chromatographic determination of blood alcohol has been reported (*13*). A method for determining blood alcohol has been described which uses alcohol and aldehyde dehydrogenases (*14*). For processing and evaluation of a large number of data obtained in the course of blood alcohol determinations, a data management program was developed (*15*). An algorithm has been suggested for interpretation of serum ethanol concentrations under legal statutes that specify whole blood concentrations (*16*). The pharmacokinetics of ethanol and the reliability of estimating the amount of alcohol ingested from a single measurement of a person's BAC has been discussed (*17–19*). Ethanol was determined in venous blood by headspace gas chromatography (GC) in a study to determine the effect of food in the stomach on the rate of ethanol elimination (*20*). Ethanol elimination rate and the implications in forensic toxicology have been studied (*21, 22*).

The performance of the Technicon Chem 1+ chemistry analyzer with the Syva Emit ethyl alcohol assay in plasma and urine was evaluated (*23*). Blood alcohol concentrations have been

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determined by determining the alcohol content in other fluids such as synovial fluid (*24*), vitreous alcohol (*25*), serum and urine (*26*), and saliva (*27–30*). Ethanol amounts have been determined in water/kefir mixtures (*31*).

The relation between the blood alcohol concentration and the vitreous humor alcohol concentration, blood 1-propanol concentration, and the signs of putrefaction of the body was described by a multiple regression equation (*32*). Alcohol in the heart blood and intraabdominal bloody fluid of a stabbing victim was determined by headspace GC to determine whether microorganisms can produce alcohol in body cavities of a living person (*33*). The production of urinary ethanol after sample collection from glucose-positive individuals was assessed (*34*). Endogenous blood production of alcohol was assessed in 286 autopsied medical examiner cases by headspace GC (*35*). Postmortem alcohol production in fatal aircraft accidents was assessed by determining ethanol in urine, vitreous humor, blood, and tissues by headspace GC (*36*). Urine and vitreous humor specimens were tested for ethanol by headspace GC-flame ionization detection (FID) to study low postmortem concentrations of ethanol (*37*). A method for the detection and quantitation of serum ethanol in humans using proton nuclear magnetic resonance (^{1}H NMR) spectroscopy was developed (*38*).

A misidentification of ethyl chloride as ethanol has been reported in three out of six occasions by headspace GC (*39*). Dual packed column headspace GC was used to differentiate diethyl ether/acetone and ethanol/acetonitrile solvent pairs and other common volatiles found in forensic applications (*40*). Headspace GC has been used to measure the concentrations of acetone in samples of venous whole blood (*41*). Isopropanol and acetone blood serum levels were determined after presurgical disinfection with isopropanol-containing antiseptics (*42*). Glucose and lactic acid concentrations were determined in vitreous humor and acetone was determined in blood from 328 autopsy cases for use as indicators of antemortem hyperglycemia in diabetics (*43*).

The determination of volatile substances in biological samples by headspace GC has been reviewed (*44*). A method for an unbiased search for volatile organics in postmortem tests has been reported which uses retention indexes and mass spectra (*45*). Proton NMR spectroscopy has been used to identify ethanol in vivo and to detect other exogenous low molecular weight volatiles in human serum (*46*).

A method has been described for the determination of ketone bodies in postmortem blood by headspace GC and enzymic dehydrogenation into acetoacetate with quantitative conversion to acetone (*47*). Contamination of methyl ethyl ketone and methanol were detected by headspace GC/MS from postmortem samples which were fingerprinted (*48*). Acetonitrile was determined in blood and urine from a poisoning victim by GC/mass spectrometry (MS) (*49*). Headspace capillary GC-FID was used for the determination of chloroform levels in blood (*50*). Trichloroethylene was detected in the biological samples of a victim of fatal inhalation by GC and GC/MS (*51*). Chlorodifluoromethane and chloropentafluoroethane were determined by headspace GC/MS in postmortem blood, brain, liver, and lung (*52*). Trichlorofluoromethane (FC11) was determined in biological tissues of a poisoning victim by headspace GC/MS (*53*). Body fluids including brain, body fat, liver, and lung from three cases of acute benzene poisoning were analyzed for benzene by headspace GC (*54*). The residue levels of pristane in the tissue of poisoned swans and aliphatic hydrocarbons in the guillemots' livers have been determined by GC/MS (*55*). Isoflurane was quantitated in blood and tissue autopsy specimens by headspace GC (*56*). Propane was determined by headspace capillary GC-FID in blood, brain, and lung tissue from a suicide victim (*57*). Ethyl chloride was detected and quantitated in vitreous humor and postmortem blood by headspace GC (*58*).

Headspace capillary GC with a thermal conductivity microdetector has been used for the microanalysis of carbon monoxide in blood (*59*). A new calibration method for the gas chromatographic assay of carbon monoxide in blood has been described (*60*). A method for the estimation of perimortal percent carboxyheme in nonstandard postmortem specimens using analysis of carbon monoxide by GC/MS and iron by flame atomic absorption spectrophotometry (AAS) has been described (*61*).

Cyanide in blood has been determined by headspace GC/nitrogen/phosphorus detection (NPD) (*62*), headspace GC-electron capture detection (ECD) (*63*), and GC/MS, and GC-ECD (*64*). Cyanide has been determined in blood by spectrophotometry after using diffusion coupled with coloration by hydroxocobalamin in a Conway dish (*65*). Hydroxocobalamin and cyanocobalamin have been determined directly in the biological fluids of a cyanide-poisoning victim by using first-derivative spectrophotometry without extraction (*66*).

Cannabinoids. Several important events and early studies on marijuana in Japan have been reviewed (*67*). Forensic investigations of the Δ-9-tetrahydrocannabinol (THC) contents of *Cannabis sativa* plants raised from seeds originating from various tropical and subtropical regions have been reported (*68*). The stage of root development of *C. sativa* stem cuttings necessary to produce viable plants has been studied (*69*). A spectrophotometric method has been used for the determination of cannabidiol in leaves from *C. sativa* (*70*).

A sensitive method for determination of cannabinoids in plasma has been developed which uses solid-phase extraction (SPE) and derivatization with separation by high-performance thin-layer chromatography (HPTLC) (*71*). A method to determine the levels of THC in human solid tissues has been reported which uses liquid/liquid extraction, derivatization, and GC/MS (*72*). Various problems, analysis methods, and guidelines for the detection of 11-nor-9-carboxytetrahydrocannabinol (THC-COOH) in urine in Japan have been discussed (*73*). The detection of THC-COOH in urine has been done by SPE, derivatization, and GC/MS (*74*), liquid/liquid extraction, derivatization, and GC/MS (*75*), and SPE, derivatization, and GC/MS/MS (*76*).

The selection of an appropriate initial test cutoff concentration for workplace drug urinalysis for cannabis has been discussed (*77*). The effect of reducing the screening cutoff for cannabinoids in urine has been studied (*78*). A validity study of the EZ-SCREEN cannabinoid test for the detection of cannabinoids in urine has been reported (*79*). Adsorption losses from urine-based cannabinoid calibrators during routine use has been reported to lead to inaccuracies (*80*). The addition of varying amounts of household bleach can cause significant decreases in the quantitated amounts of THC-COOH in urine (*81*). High urinary cannabinoids were reported from a hashish body packer by TDx and EMIT II using GC/MS to quantitate the THC-COOH (*82*). Blood and urine from drivers killed in motor vehicle accidents were screened for cannabinoids by EMIT with confirmation and

quantitation of THC and 11-hydroxy-THC by high-performance liquid chromatography (HPLC)-ECD (*83*).

Morphine and Related Narcotics. The conditions for homogenizing granular or powdery illicit heroin samples using a blender as well as the experimental results and statistical analysis have been reported (*84*). Major developments in the comparison of illicit heroin seizures by capillary GC in Germany have been discussed (*85*). Changes in the content of impurities, adulterants, and diluents have been described for 383 samples of illicit heroin (*86*). Capillary zone electrophoretic (CZE) methods have been developed for the quantitation of complex heroin seized by law enforcement (*87, 88*). Various TLC systems have been evaluated for the analysis of heroin and its adulterants commonly encountered in street samples (*89*). A simple and rapid method for the extraction of five major alkaloids in opium using SPE and HPLC has been reported (*90*). The concentrations of five major alkaloids of opium were used as descriptors for a principal component analysis (PCA) in the origin determination of 27 opium samples (*91*).

Whole blood samples from volunteers who smoked controlled doses of heroin were analyzed for morphine and metabolites by GC/MS as a way of studying the pharmacokinetics and pharmacodynamics of smoked heroin (*92*). Blood levels of heroin, 6-acetylmorphine, and morphine were measured by GC/MS in the evaluation of pharmacokinetic and pharmacodynamic properties of intranasal heroin (*93*). Plasma morphine disposition in 13 patients intoxicated by the intravascular or oral routes was evaluated using both a highly specific morphine antibody radioimmunoassay (RIA) and a nonspecific morphine RIA (*94*).

An overview of the analysis of opiates by GC/MS has been presented (*95*). The use of SPE has been evaluated for the isolation of morphine from whole blood (*96*). Morphine and flurazepam were determined in autopsy blood and other body fluids by capillary GC/MS (*97*). A SPE procedure was developed for the isolation of heroin, 6-acetylmorphine, and morphine from blood, plasma, saliva, and urine with subsequent assay by GC/MS (*98*). The separation and identification of morphine and codeine from postmortem blood and bile was accomplished using HPLC with combined ultraviolet and fluorescence detection (*99*). A comparative study of different SPE cartridges for the extraction and purification of morphine and codeine in plasma and urine samples has been presented (*100*). An isocratic HPLC method was developed for the determination of morphine and its metabolites in plasma using diode-array detection (DAD) (*101*). Analysis of morphine and its 3- and 6-glucuronides in plasma has been accomplished by HPLC with fluorometric detection following SPE (*102*). Procedures were developed for the extraction of heroin and its metabolites from postmortem tissue utilizing SPE and GC/MS (*103*). Capillary GC/MS was used to quantify ethylmorphine in biological fluids and tissues in a death attributed to oral ethylmorphine ingestion (*104*). A GC/MS method with SPE and acetylation or trimethylation was used to determine morphine and codeine and remove the interference of hydrocodone and hydromorphone (*105*).

Different analytical procedures for quantitation of total morphine and codeine in urine have been evaluated (*106*). The National Institute of Standards and Technology (*NIST*) has developed and certified a Standard Reference Material, SRM 2381, for use in testing for bias in determinations of morphine and codeine in human urine (*107*). The simultaneous analysis of codeine, morphine, and heroin in urine after β-glucuronidase hydrolysis has been described (*108*). 6-Monoacetylmorphine (6-MAM) was determined in urine by HPLC-ECD (*109*). Four common opiate immunoassays were evaluated by testing urines collected from individuals after heroin, codeine, and morphine administration (*110*). Acid hydrolysis was compared to β-glucuronidase obtained from *Patella vulgata* for quantitative conversion of morphine 3-β-D-glucuronide to morphine (*111*). Estimation of opiates in urine by stopped-flow fluorimmunoassay has been reported (*112*). Heroin and its metabolites were determined in urine samples by liquid/liquid extraction and GC/MS (*113*). A method has been described for the simultaneous determination of 6-MAM, morphine, and codeine in postmortem urine using reversed-phase HPLC with dual UV spectrophotometric and electrochemical detection (*114*). The determination of morphine 3-glucuronide in urine by CZE and micellar electrokinetic capillary chromatography (MECC) has been reported (*115*). Morphine in urine was detected by EMIT d.a.u. and confirmed by GC/MS after ingestion of poppy seeds (*116*). A review of problems during forensic morphine urinalysis arising from natural occurrence of morphine and codeine in poppy seeds has been reported (*117*). The subcritical fluid extraction of morphinic alkaloids in urine and other liquid matrixes after adsorption on solid supports has been demonstrated (*118*).

Morphine analysis was performed using a variety of immunoassay methods in blood, urine, and cisternal cerebrospinal fluid from victims of opiate-related deaths (*119*). Morphine was determined in the liver by RIA and GC/MS from a homicide victim (*120*). A study of deaths involving oxycodone has been reported (*121*). Morphine and codeine were simultaneously identified and assayed in blood and bile of a putrefied cadaver and in the fly larvae of Calliphoridae found on the corpse (*122*).

Opiate concentrations in human head, axillary, and pubic hair were determined by liquid/liquid extraction, derivatization, and GC/MS (*123–125*). GC/MS has been used to determine total morphine and 6-acetylmorphine in hair (*126, 127*). Morphine and 6-MAM have been detected in hair using a guanidine/mercaptoethanol treatment followed by SPE (*128*). Capillary GC/MS/MS has been used to detect heroin and its metabolites in hair (*129*). Supercritical fluid extraction (SFE) of opiates from hair has been compared with other extraction techniques followed by SPE (*130*). Morphine extracted from dated human hair segments and analyzed by adaptation of a specific SPE-RIA for the measurement of morphine in urine has provided long-term histories of heroin usage of individual patients (*131*). A review on the analysis of hair for opiates has been reported (*132*).

Cocaine. A quantitative method for the determination of cocaine and related substances by MECC has been described (*133*). A continuous-flow immunosensor has been designed for the detection of cocaine in aqueous samples (*134, 135*). A new application for the quantitation of cocaine base has been reported (*136*). Selective-ion-monitoring techniques with GC/MS have been used for the identification and quantitation of thermal decomposition products of cocaine (*137*). The cobaltous thiocyanate screening test for cocaine has been studied (*138*).

Methodology used for the comparative chemical analyses of two illicit cocaine seizures, and its application in a successful criminal prosecution, has been described (*139*). The application of capillary GC-ECD in comparative analyses of illicit cocaine samples has been reported (*140*). A practical procedure for

rapidly searching a large database of cocaine signatures to identify database entries that closely resemble a given reference cocaine exhibit using a personal computer has been described (*141*). A rapid method for comparison analysis of illicit cocaine samples was developed and used to compile a cocaine database (*142*).

The predominant methods currently used for illicit production of cocaine have been described (*143*). Pseudococaine was isolated from both coca leaf and illicit cocaine, determined by GC-FID, and confirmed by GC/MS (*144*). 3′,4′,5′-Trimethoxy-substituted analogs of cocaine, *cis-/trans*-cinnamoylcocaine, and tropacocaine have been characterized by GC/MS following a toluene extraction with ion-pair chromatography and quantitated by capillary GC-FID (*145*). Chromatographic methodologies used for the in-depth alkaloid analyses of coca leaves and for the characterization of alkaloidal impurities and manufacturing byproducts in illicit refined cocaine samples have been reviewed (*146*). Methodology has been described for the detection and/or determination of cocaine and minor alkaloids in coca (*147*).

GC/MS was used to determine the long-term stability of blood cocaine in evacuated collection tubes (*148*). Cocaine and benzoylecgonine were determined in blood by SPE, derivatization, and GC/MS using selected-ion monitoring (*149–151*). Serial plasma concentrations of cocaethylene, cocaine, and ethanol have been measured (*152*). A GC/MS method has been described for the simultaneous analysis of cocaine and the hydrolytic products benzoylecgonine, methylecgonine, and ecgonine from plasma (*153*). LC-PDA has been used to detect and confirm cocaine and cocaethylene in serum (*154*). Reversed-phase HPLC with fluorometeric detection has been used to determine cocaine in plasma and human hair (*155*). A procedure has been developed for the processing of whole blood for the estimation of benzoylecgonine with the use of the Abbott ADx reagents and analyzer (*156*). An EMIT d.a.u. immunoassay for urine testing was applied on the Syva ETS Plus analyzer for the detection of benzoylecgonine in human serum (*157*). Cocaine and its metabolites have been analyzed in blood by SPE and reversed-phase HPLC (*158*). A review of the toxicological data from cocaine-related deaths has been reported (*159*). Cocaine, cocaethylene, and caffeine were determined by GC/MS (*160*) in blood and other body fluids from an accidental death victim.

Benzoylecgonine has been determined in urine by GC/MS (*161, 162*), SPE and GC/MS (*163–165*), liquid/liquid extraction and GC/MS (*166*), SPE and LC/atmospheric pressure chemical ionization mass spectrometry (LC/API-MS) (*167*), HPLC-PAD (*168*), HPLC with postcolumn ion-pair extraction and fluorescence detection (*169*), and HPLC with a fluorescent derivative of benzoylecgonine (*170*). Drug testing situations in the laboratory, purposes for testing drugs of abuse, and recent pharmacokinetics for cocaine have been discussed (*171*). EMIT and GC/MS have been used to detect the presence of cocaine and benzoylecgonine in urine, hair, and meconium (*172*). The maximum stability conditions for cocaine and its metabolites benzoylecgonine in urine have been studied (*173*). A report has shown that an antibody-mediated interference could arise in a homogeneous immunoassay used to determine the presence of cocaine metabolites in urine (*174*).

The feasibility of using saliva to detect cocaine and benzoylecgonine has been studied (*175*). An assay has been developed for the simultaneous measurement of cocaine, heroin, and metabolites in plasma, saliva, urine, and hair by SPE and GC/MS (*176*). An assay for the simultaneous measurement of cocaine, cocaethylene, metabolites, and pyrolysis products in biological fluids has been developed (*177*). LC has been used to determine cocaine, benzoylecgonine, and other local anesthetic agents in biological fluids (*178*). Cocaine, heroin, and their metabolites have been determined in sweat (*179*). The application of HPLC, with confirmation by GC/MS, for the identification of cocaine, cocaethylene, and norcocaine in the merconium of premature babies has been reported (*180*). RIA was used to quantitate benzoylecgonine in residual dried blood spots obtained routinely from infants (*181*). Cocaine, benzoylecgonine, and methylecgonine were detected and quantitated in saliva by GC/MS (*182*). *m*-Hydroxybenzoylecgonine has been found to be an important contributor to the immunoreactivity in immunoassays for benzoylecgonine in meconium (*183*). Cocaethylene was determined by HPLC in kidney, lung, and placenta to investigate the potential of cocaethylene to form in the presence of cocaine and ethanol (*184*). A method has been described for the determination of cocaine, benzoylecgonine, and cocaethylene in the human brain using SPE and GC-ion trap MS (*185*). Benzoylnorecgonine and other cocaine metabolites have been quantitated in meconium by SPE and HPLC (*186*). An isocratic HPLC system for quantifying benzoylecgonine and cocaine in vitreous humor has been developed (*187*).

Cocaine and its metabolites have been detected in hair by GC/MS (*188–190*) and HPLC and CE (*191*). Variables in the external contamination of hair by cocaine have been explored (*192*). An evaluation of patterns of racial bias in hair assays for cocaine has been reported (*193*). The in vitro differential binding of benzoylecgonine to pigmented human hair samples has been evaluated (*194*). The Abbott TDx analyzer was used to determine the frequency of cocaine and PCP in newborns and patients admitted to a large urban public teaching hospital (*195*).

Amphetamines. Eleven side-chain positional isomers of methamphetamine can be distinguished from methamphetamine using a combination of the marquis color test, GC, HPLC, and MS (*196*). The intermediates, products, and byproducts obtained in the synthesis of 3,4-methylenedioxyamphetamine (MDA) from isosafrole have been identified by GC/MS (*197*). GC/MS has been used to identify amine–solvent condensation products formed during analysis of drugs of abuse (*198*). A HPLC method for the simultaneous identification and quantification of amphetamine, methamphetamine, MDA, *N*-methyl-3,4-methylenedioxyamphetamine (MDMA), and *N*-ethyl-3,4-methylenedioxyamphetamine (MDE) in the presence of caffeine and ephedrine in illicit tablets has been described (*199*). Amines, including methamphetamine, have been characterized by Fast Black K salt in TLC (*200*). A rapid and simple method for the identification of amphetamine and methamphetamine hydrochlorides using mass spectrometry has been reported (*201*).

Computerized methods for classification of illicit Leuckart-synthesized amphetamine have been presented (*202*). GC/MS was used to analyze the synthesis products and intermediates from the methamphetamine synthesis via reductive alkylation hydrogenolysis of phenyl-2-propanone with *N*-benzylmethylamine (*203*). The synthesis of *N*-(2-hydroxyethyl)amphetamine has been described, which includes IR and mass spectra of the drug (*204*). The validity of inorganic impurity analysis in discriminating seized methamphetamine samples in Japan was investigated using inductively coupled plasma (ICP), MS, and AAS (*205*). TLC, GC,

and GC/MS was used to study the precursors, intermediates, and reaction byproducts in the synthesis of 3,4-MDMA (*206*).

A method to classify amphetamine samples according to their impurity content by the help of computer programs has been described (*207*). A computerized procedure has been presented for profiling and comparison of illicit amphetamine seizures by GC (*208*). A discussion of illicit amphetamine profiling in the U.K., which uses solvent extraction and GC, has been presented (*209*). A technique for impurity profiling methylamphetamine hydrochloride to determine the method of manufacture based on the three most common synthetic routes encountered in Australia has been described (*210*). Impurity profiling analysis by liquid/liquid extraction and capillary GC of methamphetamine seized in Japan has been investigated (*211*). Impurity profiles of illicit methamphetamine were generated by capillary GC after extraction with ethyl acetate (*212*). A computerized method has been developed to facilitate comparison of common batches in the leuckart synthesis of methamphetamine (*213*). The characterization of methamphetamine samples using GC impurity profiles was investigated (*214*). Chiral resolution of a number of amphetamine type drugs has been accomplished by CE (*215*), HPLC with fluorescence detection (*216*), and use of a chiral stationary phase carrying immobilized native β-cyclodextrin (*217*).

Amphetamine and methamphetamine have been analyzed in urine using a homogenous electrochemical immunoassay (*218*), RIA (*219*), fluorescence polarization immunoassay (FPI) (*220*), EMIT (*221–223*), GC-FT-IR (*224*), derivatization and GC/MS (*225, 226*), GC/MS (*227*), electrochemical immunoassay (*228*), methamphetamine-sensitive electrode (*229*), spectrophotometry using the H-point standard addition method (*230*), HPLC with chemiluminescence detection (*231*), ELISA (*232*), SPE, polymeric-reagent derivatization and reversed-phase HPLC (*233*), and GC-FID and GC/MS (*234*). The cross-reactivity, stereoselectivity, and clinical performance of the EMIT d.a.u. monoclonal amphetamine/methamphetamine immunoassay for the detection of MDA and MDMA in urine has been evaluated (*235*). Analysis of the phenolic metabolites of 3,4,5-trisubstituted amphetamines using LC-ECD has been reported (*236*).

A method for the analysis of enantiomers of methamphetamine and amphetamine in urine has been reported which uses HPLC and thermospray LC/MS (*237*). Several positive urine samples for methamphetamine and amphetamine were reanalyzed to determine the chirality of the drug by derivatization and GC/MS (*238*). The interpretation of methamphetamine and amphetamine enantiomer data has been discussed (*239*). A review of the metabolic precursors to amphetamine and methamphetamine including medical uses, metabolism, and interpretation has been reported (*240*). A retrospective analysis of some L-methamphetamine/L-amphetamine urine data has been presented (*241*). The determination of amphetamine and methamphetamine concentrations in a lyophilized human urine reference material has been done by SPE and GC/MS (*242*). An artifact peak similar to methamphetamine has been detected by GC/MS (*243*). During periodate degradation of interfering ephedrine, pseudoephedrine, and phenylpropanolamine in the extraction of methamphetamine from urine, it was observed that a small amount of methamphetamine was demethylated to amphetamine (*244*). The detection of selegiline and its metabolites in urine has been reported by FPIA and GC/MS in the differentiation of the intake of selegiline from abuse of methamphetamine or amphetamine (*245*).

Amphetamine and methamphetamine have been determined in blood by GC-chemical ionization mass spectrometry (CIMS) (*246*), GC-negative ion CIMS (*247*), and derivatization and GC/MS (*248*). MDA and MDMA have been determined in blood by HPLC-ECD (*249*). A sensitive enantiomer-specific HPLC analysis of methamphetamine and amphetamine from serum has been reported which uses precolumn fluorescent derivatization (*250*). A one-step determination of the enantiomeric analysis of amphetamine in plasma has been developed which uses on-line, precolumn solid-phase derivatization with reversed-phase HPLC separation (*251*). GC/MS was used to determine MDMA and its metabolites in blood, stomach contents, and urine from an overdose victim (*252*). TLC was used to detect methamphetamine, and GC/MS was used for quantitation of methamphetamine in blood, stomach contents, and thoracic fluid from a poisoning victim (*253*).

The excretion of methoxyphenamine and methamphetamine into beards of human subjects has been studied using derivatization and GC/MS (*254*). GC/MS was used to discriminate between methamphetamine use and deprenyl use by hair analysis (*255*).

Barbiturates. Twenty-two barbiturates were analyzed on both the ion trap and quadrupole mass spectrometers, and their electron ionization mass spectra were compared (*256*). The effects of sample concentration on spectral matching accuracy of barbiturates using the UV-photodiode-array detector have been reported (*257*). A solid-phase extraction, derivatization, and GC/MS procedure has been developed for the simultaneous determinations of butalbital, amobarbital, pentobarbital, and secobarbital, using a deuterated pentobarbital as the internal standard (*258*). A mass spectrometric screening method for barbiturates in serum has been developed (*259*). CE has been applied to the determination of six barbiturates in serum (*260*). HPLC was used to determine barbiturates in postmortem tissue of rats as a model to show postmortem changes in concentrations (*261*). A rapid screening technique for the identification and quantitation of barbiturates in plasma has been reported which uses wide-bore capillary GC-NPD (*262*).

Miscellaneous Drugs and Poisons. A review of the synthetic routes of phencyclidine with emphasis on forensic investigations of clandestine PCP laboratories has been presented (*263*). A polarization fluoroimmunoassay was developed for the detection of PCP in urine, and the reagents were adapted for use on the Abbott TDx analyzer (*264*). An evaluation of enzyme immunoassay performance characteristics for the detection of PCP has been reported (*265*). A confirmation procedure for the analysis of cocaine, benzoylecgonine, ecgonine, and PCP in human hair using tandem MS has been developed (*266*).

Triazolam and ethanol concentrations were determined in blood from six cases of fatal triazolam poisoning using GC-ECD (*267*). Flurazepam and its metabolites were determined in blood and body fluids of a suicide victim using a combination of EMIT, gradient HPLC-PAD, and capillary GC/MS (*268*). Serum was tested for benzodiazepines by FPIA in Abbott's ADx system using the benzodiazepine serum reagents and the benzodiazepine urine reagents after pretreatment of specimens by means of acetone precipitation (*269*). A method for the GC/MS confirmation of five common benzodiazepine metabolites in urine has been described that uses SPE and *tert*-butylsilyl derivatization (*270*). The simultaneous identification and quantitation of 15 benzodi-

azepines and selected metabolites in postmortem blood, serum, or liver homogenates using gradient HPLC has been described (*271*). The application of GC-negative ionization CIMS for the simultaneous quantitation of seven commonly encountered urinary benzodiazepines has been described (*272*). The detection of nordiazepam, triazolam, lorazepam, and alprazolam in blood by immunoassay has been reported (*273*).

The EMIT d.a.u. and FPIA benzodiazepine assays were used to screen urines for Adinazolam and its major metabolites with confirmation by HPLC (*274*). A method for the quantitation of alprazolam and triazolam in hemolyzed whole blood and liver tissue has been reported that uses GC/MS-NICI with deuterated internal standards (*275*). An improved screening procedure for detecting benzodiazepine metabolites in urine using the Triage Panel for Drugs of Abuse has been developed (*276*). A SPE and GC/MS confirmation method has been developed for certain urinary benzodiazepines (*277*). The radioreceptor assay (RRA) has been compared to EMIT d.a.u. and HPLC for the detection of benzodizepines in urine (*278*). The detection of benzodiazepines by triage with confirmation by SPE and GC/MS has been reported (*279*). A GC/MS method has been described for the confirmation of benzodiazepines in urine (*280*). Conditions for the enzymatic hydrolysis of benzodiazepine conjugates in urine have been described (*281*). Benzodiazepines have been detected in urine using enzyme hydrolysis, EMIT II, and TDx, with confirmation by GC/MS (*282*). CE has been applied for the simultaneous separation and detection of nitrazepam and its major metabolites in urine (*283*). An homologous series of benzodiazepine retention index standards for GC has been synthesized and evaluated (*284*). MECC has been used for the simultaneous separation and detection of nitrazepam and its major metabolites in urine (*285*). TLC has been used to detect benzodiazepines in urine after hydrolysis (*286*). EMIT, GC/MS, and LC/MS have been used for the determination of triazolam and its metabolites in urine (*287*). Six immunoassay methods have been compared to GC/NICI-MS for the detection of benzodiazepines in urine (*288*). Identification and quantitation of intact diastereoisomeric benzodiazepine glucuronides in biological samples has been done by HPLC (*289*). Chlordiazepoxide and its metabolites in human serum were analyzed by capillary HPLC/FAB-MS (*290*).

The effect of different parameters on the extraction efficiency of LSD from impregnated papers has been investigated (*291*). A simplified extraction technique for the analysis of LSD by GC/MS has been described (*292*). Capillary GC-FID has been used to quantitate LSD in illicit samples (*293*). IR and NMR were used for authentication of a house supply of LSD tartrate (*294*). GC/MS has been used to confirm and quantitate LSD in urine (*295*).

NMR has been used for the identification of three major alkaloids in dried leaves of the khat plant, *Catha edulis* (*296*). The major alkaloids of the plant, khat, were conclusively identified by GC/MS after derivatization (*297*). HPLC and TLC profiles of the phenylalkylamines of khat have been reported (*298*).

The current status of published information on the urinary metabolites of 17 anabolic steroids has been reviewed (*299*). The determination of anabolic steroids by MECC, gradient HPLC, and capillary GC has been reported (*300*). Testosterone esters have been analyzed by tandem MS (*301*). Surface ionization organic mass spectrometry has been performed on imipramine, desipramine, clomipramine, and lidocaine (*302*). A detailed discussion of bufotenine including origin, chemistry, pharmacology, and toxicology as well as examples of case samples has been given (*303*). The characterization of counterfeit Captagon tablets has been accomplished by physical differences and chemical comparison by TLC, melting point, IR, UV, proton NMR, carbon-13 NMR, and elemental analysis (*304*). A survey of 76 cases of fatal intoxication with Ketogan has been reported (*305*). Hydroxyzine and it metabolites were determined in postmortem blood and liver by GC/MS (*306*). Terfenadine and two of its major metabolites were determined in the blood of a fatal poisoning victim by capillary GC-NPD (*307*).

Blood and stomach contents from an overdose victim were determined for diflunisal by HPLC (*308*). The efficacy of 1% NaF as a preservative in urine samples containing glucose and *Candida albicans* was assessed by GC-FID (*309*). HPLC was used to detect the presence of amitriptyline and nortriptyline in larvae from decomposing tissue (*310*). The structural identification of a methyl analog of methaqualone via two-dimensional NMR techniques has been reported (*311*). The standard addition technique and HPLC, HPTLC, and GC/MS were used to determine doxylamine and two of its metabolites in body fluids from an overdose victim (*312*). Etryptamine was determined by GC-NPD in blood and other body fluids from a fatal intoxication victim (*313*). Postmortem blood cholinesterase activity has been evaluated as a screening test for organophosphate/chemical weapon exposure (*314*). Fentanyl was determined in blood by capillary GC/MS in 30 postmortem specimens (*315*). Hydroquinone was extracted from autopsy urine, liver, and kidney and identified by GC/MS (*316*). Colchicine was confirmed by HPLC-PAD in postmortem blood and bile (*317*). Clomipramine and its metabolites were determined in blood and body fluids of a suicide victim by HPLC and GC (*318*). Postmortem blood and liver concentrations of clomipramine were determined in 10 cases by HPLC (*319*). Buprenorphine and its metabolites were detected in hair by RIA and confirmed by LC-ECD (*320*).

Ketamine was determined in blood and body fluids from a poisoning victim by SPE and GC/MS (*321*). The first detection of drugs (amitriptyline and nortriptyline) from chitinized insect tissues has been reported (*322*). The use of bone marrow in the study of postmortem redistribution of nortriptyline has been reported (*323*). A method has been reported for the quantitation of paraquat in plasma using SPE and HPLC (*324*). Whole blood concentrations of triazolam were determined in forensic cases by liquid/liquid extraction and GC/MS using the NICI mode (*325*). A study has compared the Abbott ADx FPIA propoxyphene assay to GC/MS (*326*). The interference of herbal drinks with urinalysis for drugs of abuse has been evaluated using FPIA and TLC (*327*). The performance-based testing for marijuana, amphetamine, alcohol, and diazepam have been reported (*328*). An HPLC method for the quantiation of paraquat in urine was applied to serum (*329*). The effect of freezing on the concentration of drugs of abuse in urine has been studied using GC/MS (*330*). Chlorpheniramine, dehyrocodeine, methylephedrine, salicylate, and verapamil were quantitated in the blood of a suicide victim by GC/MS (*331*). Cyamemazine was identified and quantitated in postmortem blood by HPLC-DAD (*332*). A quantitative assay for the determination of meprobamate in human fluids and hair has been described (*333*). Flecainide was determined in blood and tissues of a suicide victim by GC-NPD and GC/MS (*334*). Bupropion and its metabolites were detected and quantitated in blood of a suicide victim by GC/MS (*335*).

The distribution of arsenic along the length of a hair has been determined by graphite furnace AAS (*336*). The identification and quantitation of Triamterene in blood and urine from a fatal aircraft accident victim was done by HPLC-DAD (*337*). Digoxin and doxepin were determined by HPLC in the blood plasma, bile, urine, and stomach contents of an overdose suicide victim (*338*). GC/MS and HPLC-DAD were used to determine sertraline and its major metabolite in postmortem specimens (*339*). EMIT, TLC, HPLC-DAD, and GC/MS were used for the unequivocal identification of trazodone and dothiepin in the blood and urine of a poisoning victim (*340*). Diltiazem was determined in postmortem specimens from an overdose victim (*341*). Zipeprol was determined in blood and tissues of an overdose victim by liquid/liquid extraction and GC/MS with a megabore capillary column (*342*). Propoxyphene and norpropoxyphene were identified and quantitated in urine using SPE and GC/MS (*343*). Butriptyline was determined in biological fluids from an overdose victim by GC/MS and FT-IR (*344*). Sertraline and metabolites were determined in blood and liver from postmortem cases by GC-NPD with confirmation by GC/MS (*345*). Tetramine in postmortem specimens was determined by GC-NPD (*346*). Benztropine was identified and quantitated in blood and urine of an overdose victim by capillary column GC/MS (*347*). Mexiletine was detected by GC-NPD and confirmed by GC/MS in the blood and body fluids of a suicide victim (*348*). Mexiletine was detected by GC-FID and confirmed by GC/MS in the blood and tissues of a fatal overdose victim (*349*). γ-Hydroxybutyrate (*GHB*) was quantified in the urine of a DWI suspect by GC-FID (*350*). β-Hydroxybutyrate was measured in postmortem samples of vitreous humor and urine using a quantitative enzymatic spectrophotometric procedure (*351*).

Cefaclor was determined in human serum by HPLC and fast atom bombardment (FAB) MS (*352*). Postmortem serum selenium concentrations were determined by AAS (*353*). Head hair samples obtained from surgery patients who received fentanyl during anesthesia were analyzed by RIA for the presence of fentanyl (*354*). Formalin-fixed liver and formalin solutions were analyzed for amitriptyline and nortriptyline by GC-NPD and for imipramine and desipramine by HPLC (*355*). Trace amounts of paraquat and diquat were determined in blood by extraction with phenol followed by absorption spectrophotometry with simultaneous analysis by second-derivative spectroscopy (*356*). Positive-ion electron impact (*PIEI*), positive-ion chemical ionization (*PICI*), and negative-ion chemical ionization (*NICI*) mass spectra have been presented for 15 compounds of diphenylmethane antihistmines and their analogs, and each fragmentation pathway was analyzed (*357*). The axial distribution along the hair shaft has been monitored for ofloxacin and nicotine for therapeutic drug monitoring (*358*). Hair analysis as a tool for monitoring and managing patients on methadone maintenance has been reviewed (*359*). A retrospective medical examiner case review of all deaths in Maryland where either fluoxetine or tricyclic antidepressant (TCH) use was forensically detected has been conducted (*360*). Capillary GC/MS was used to quantify zipeprol in biological fluids and tissues from an overdose victim (*361*).

Enantiomers of thioridazine were determined in postmortem tissues by chiral HPLC (*362*). 2,4-Dichlorophenoxyacetic acid (2,4-D) was determined in a suicide victim by diethyl ether extraction from acidified viscera or by deproteinization of blood with methanol followed by HPLC (*363*). Hypoxanthine was determined by HPLC in vitreous humor and cerebrospinal fluid of autopsy specimens as an indicator of prolonged cerebral hypoxia and postmortem interval (*364*). The tissue distribution and postmortem redistribution of zopiclone was determined in a fatal suicidal overdose victim by HPLC (*365*). Propofol levels were determined in the blood, liver, kidney, and brain of a fatal poisoning victim by headspace GC-FID (*366*). A new approach has been developed for modeling human postmortem interval estimation from vitreous potassium by reanalyzing data from six previous studies (*367*). PIEI, PICI, and NICI mass spectra have been presented for 10 xanthine derivatives, and each fragmentation pathway has been analyzed (*368*). ICPMS has been used in a suicide case for the determination of arsenic after ingestion of arsenous acid (*369*). A method that uses dual-wavelength HPLC suitable for the determination of tricyclic and other antidepressants in postmortem and clinical specimens has been presented (*370*). Chemicals used in the manufacture of illegal drugs have been reviewed (*371*). PIEI and PICI mass spectrometry has been used to confirm the presence of clenbuterol in urine (*372*). Mefenamic acid has been reported to interfere with the EMIT assay for drugs of abuse in urine (*373*). Instrumental neutron activation analysis (*NAA*), with γ-ray spectrometry, was carried out on sectioned hair samples for the analysis of arsenic from six possible poisoning victims (*374*). A method for simultaneous determination of paraquat dichloride and diquat dibromide in human biological materials has been developed which uses SPE and HPLC (*375*). Dextromoramide, propoxyphene, and its main metabolite, norpropoxyphene, were determined in blood after solid/liquid extraction by means of an HPLC-DAD method (*376*). Identification of meprobamate in urine has been done by liquid/liquid extraction and a color reaction with furfural (*377*). An investigation of possible counterfeit suppliers of gentamicin sulfate has been reported which uses a high-pH anion-exchange separation on a carbohydrate column with pulsed electrochemical detection on a gold electrode (*378*). LC/MS has been used to determine malathion and its metabolites in biological samples (*379*).

A solid-phase RIA method used for the determination of methadone in urine has been adapted and evaluated for the detection of methadone in hair (*380*). A HPLC method has been developed for the determination of zopiclone in whole blood (*381*). Two methods for the analysis of aconitum alkaloids have been studied by using HPLC and LC/FAB-MS (*382*). Quantitative analysis, using GC/MS, of hydroquinone from several organs and tissues from a victim of photographic developer poisoning has been reported (*383*). The usefulness of thiosulfate as an indicator of hydrogen sulfide poisoning in forensic toxicological examinations has been discussed (*384*).

General Procedures. Drug analyses relevant to forensic investigations have been reviewed (*385*). Methods for the analysis of drugs of abuse have been reported using CE (*386*), micro-FT-IR (*387*), quantitative TLC (*388*), overpressured TLC (*389*), HPTLC (*390*), LC-PAD (*391*), HPLC with UV detection at three wavelengths followed by fluorescence and electrochemical detection (*392*), HPLC with continuous on-line postelution photoirradiation followed by either DAD or thermospray MS (*393*), GC-surface ionization detection (SID) (*394*), wide-bore column GC-NPD (*395*), circular dichroism (CD) (*396*), and indirect flame AAS (*397*). The comparison of IR and mass spectroscopies for drug analysis has been discussed (*398*). Cannabinoids were extracted from marijuana using SFE (*399*). The retention indexes (*RI*) of

drugs were determined on seven reversed-phase columns by HPLC (*400*) and a HPLC database based on these data has been described (*401*). The retention indexes of a number of drugs were determined on a reversed-phase solvent gradient HPLC system (*402*). The Frye rule and its applicability to microcrystal tests for drugs has been discussed (*403*, *404*). The limit of detection (LOD) and the limit of quantitation (LOQ) have been determined for GC/MS analyses of drugs of abuse (*405*). The standardization for determining LOD and LOQ in drug testing laboratories has been discussed (*406*). Formulas for representative sampling protocols were evaluated, and an optimal formula to be used in a sampling plan for "street" drug exhibits with a large number of units has been presented (*407*). The application of palynology to establish the provenance and travel history of illicit drugs has been reported (*408*).

A general review of comparative analyses of illicit drug substances has been presented including both trace level chemical and ballistics examinations (*409*). Chemical impurity profiling of abused drug samples using capillary GC and HPLC (*410*) and CE (*411*) has been reported. The comparison of drug seizures in the Forensic Laboratory of The Netherlands has been described (*412*). Ion chromatography has been used for the verification of drug authenticity (*413*). The Racketeering Records Analysis Unit of the FBI Laboratory has developed a protocol for the analysis of suspected clandestine and/or coded drug records (*414*).

A general review of forensic toxicology has been published (*415*). The importance of quality assurance in testing for drugs of abuse has been discussed (*416*). Analytical methods for the detection of toxicologically important substances in forensic casework have been reported (*417*). A review on the methods of standardization of HPLC data as used in systematic toxicological analysis has been reported (*418*). The potential and pitfalls of chromatographic techniques and detection modes in substance identification for systematic toxicological analysis has been discussed (*419*). The identification of drugs in toxicological analysis has been accomplished using HPLC (*420*), HPLC-DAD (*421*), HPLC/FAB-MS (*422*), REMEDi and GC/MS (*423*), GC-SID (*424*, *425*), HPLC/MS (*426*), tandem MS (*427*), MECC (*428*), CE (*429*), and PCA of standardized TLC data (*430*). NPD has been compared to SID as a detector for GC for drug analysis in toxicology (*431*). Sample preparation of biological tissues for drug poisoning screening by capillary GC/MS has been studied (*432*). A software program has been developed that allows the unattended searching of all peaks in a GC/MS run of urine or serum extract (*433*).

A discussion of the benefits of enzyme hydrolysis of tissues, hair, etc., for the release of drugs has been presented (*434*). A system for emergency toxicology screening for drugs and poisons has been reported that uses GC/MS, TOXI-LAB, TDx, and spectrophotometry (*435*). Several reviews have been published on drug testing in forensic toxicology (*436*–*439*). Drugs of abuse have been detected in urine using TLC (*440*, *441*), immunoassays (*442*–*445*) including EMIT (*446*–*449*), EMIT and GC/MS (*450*), EMIT and RIA (*451*, *452*), SPE and HPLC with fluorescence detection (*453*), SPE and LC/MS (*454*), HPLC-DAD (*455*), on-line immunoaffinity chromatography/HPLC/MS (*456*), GC/MS (*457*), and GC/MS, TLC/GC, and EMIT (*458*). The Triage Panel for Drugs of Abuse has been evaluated for detection of drugs in urine (*459*–*461*). Immunoassays have been compared to chromatographic techniques, using GC/MS as a reference for analyzing drugs in urine (*462*). Characterization of drug interferences in the GC/MS analysis of drugs in urine has been reported (*463*). The stability of drugs of abuse in urine samples has been studied (*464*).

The detection of drugs of abuse in blood has been done by SPE and GC-NPD (*465*–*467*), automated SPE and GC (*468*), and HPLC-DAD (*469*). The analysis of whole blood for drugs of abuse has been done using EMIT d.a.u. and a Monarch 100 chemistry analyzer (*470*). Drugs in breast milk were screened by EMIT and confirmed by GC-FID and GC/MS (*471*). An instrumental TLC procedure was described for the identification of drugs in autopsy liver samples (*472*). A survey of current literature on saliva testing for drugs of abuse has been reported (*473*). A screening procedure has been developed for drugs of abuse in meconium from infants which uses liquid/liquid extraction and EMIT followed by confirmation with GC/MS (*474*).

Reviews and discussions have been reported on the use of hair analysis, including the detection of drugs, as evidence in forensic cases (*475*–*478*). Evaluation of analytical methods, environmental issues, and development of reference materials for the analysis of drugs of abuse in hair has been reported (*479*). Sample preparation techniques for the analysis of hair for drugs of abuse have been discussed (*480*). An overview of extraction procedures for the analysis of drugs in hair has been reported (*481*). An extraction procedure for the analysis of drugs in hair, which uses enzymic hydrolysis, has been proposed (*482*). Analytical requirements, perspectives, and limits of immunological methods for the analysis of drugs in hair have been reviewed (*483*). Drugs of abuse have been detected in hair by GC/MS (*484*–*486*), ion trap MS (*487*), IR spectroscopy (*488*), CE (*489*), and ELISA (*490*). Studies for drug incorporation into hair have been reported (*491*–*493*).

A review on the analysis of poisons in forensic applications has been published (*494*). GC and GC/MS have been used to determine aqueous poisons (*495*). A review has been published that considers the various parameters affecting drug pharmacokinetics and pharmacodynamics in humans and the problems involved in establishing forensic threshold values for blood drug levels ensuring adequate traffic safety (*496*). The effects of adulterating agents on FPIA analysis of urine for drugs of abuse has been reported (*497*). Comprehensive drug screens were performed on blood specimens collected from fatally injured drivers using RIA, GC-FID, GC-NPD, and HPLC (*498*). Urine samples were collected from service members and analyzed for drugs of abuse using RIA and GC/MS (*499*). Warfarin has been identified and quantified in postmortem blood by HPLC (*500*).

TRACE EVIDENCE

Petroleum Products. Both passive and dynamic charcoal adsorption techniques were compared and found to be well suited for use in the recovery of small quantities of petroleum product (*501*). A passive adsorption/elution method using the DFLEX device made of a charcoal-impregnated polymer strip was a preferred technique for the routine examination of fire debris samples (*502*). The utility of passive headspace concentration using a charcoal-impregnated strip has been demonstrated (*503*). A macroprogram for GC/MS that performs data analysis of fire debris samples has been published (*504*). A method for the analysis of trace levels of gasoline in arson debris using an automatic thermal desorber and Tenax adsorbent tubes has been

described (*505*). A method for identifying petroleum distillates in fire debris samples by headspace analysis and multidimensional GC has been described (*506*). A GC/MS approach employing target compound analysis can be used for evaluating interferences present in fire debris (*507*). Software for the matching of GC profiles of petroleum products recovered from fire scenes has been successfully evaluated (*508*). Passive headspace using the carbon strip method was utilized to recover methanol, ethanol, 2-propanol, and acetone from fire debris (*509*). Different brands and grades of gasoline were analyzed by three-dimensional fluorescence spectroscopy, and similarities were shown between neat and 50% evaporated samples (*510*). The use of an electron capture detector has aided in the identification of kerosene in arson cases (*511*). A study was conducted to evaluate the interference potential of pyrolysis products obtained from carpets and carpet paddings at fire scenes (*512*). Based on detection of a dye in gasoline, a thin-layer chromatography method was developed for quick detection of gasoline in fire debris (*513*). A GC/MS and an X-ray fluorescence (XRF) technique has been presented that allows for the characterization of used automotive or locomotive lubricant oil (*514*). A variety of evidence bags have been evaluated as to their suitability as containers for fire debris samples (*515*). The analysis of soot deposited on cold surfaces in the course of a fire may provide useful information regarding the type of combustible involved (*516*). A method for comparing the flammability and inhalation hazards of commercial coatings and adhesives has been presented (*517*). Canines were generally able to detect accelerants at level of 0.01 μL or more (*518*).

Explosives. The identification of high explosives by polarizing microscopy has been described (*519*). The microscopic examination of inorganic explosives has been reviewed (*520*). The application of GC, HPLC, and ion chromatography for the detection of trace levels of explosives was investigated (*521*). Picogram levels of explosives have been characterized by LC/MS and LC/tandem MS using electrospray ionization (*522*). The combined power of a tandem mass spectrometer coupled with an ionization source that operates at atmospheric pressure has proven effective for trace explosive detection (*523*). Liquid chromatography/thermospray negative ion tandem mass spectrometry successfully detected picogram levels of explosives in postblast debris (*524*). The separation of mono- and divalent cations of interest in explosive residue analysis was achieved using ion chromatography with conductivity detection (*525*). TLC techniques used for forensic explosive investigation in England in 1974 were investigated for their ability to distinguish nitroglycerine from pentaerythritol tetranitrate (*526*). Application of ion chromatography and techniques including capillary electrophoresis has been explored in the analysis of low explosives and their residues (*527*). The application of ion mobility spectroscopy to explosive detection has been reviewed (*528*). Ion mobility spectrometry showed detection levels as low as 200 ppm for common explosives (*529*). To avoid the loss of traces of TNT and its decomposition products, it is best to freeze-dry samples or to perform the analysis as soon as possible (*530*). A sampling kit for use on people who are suspected of illegal involvement with firearms and/or explosives has been introduced into casework (*531*).

Gunpowder and Primer Residue Detection. Gunshot residue (GSR) has been found in hair 24 h after shooting if the hair has not been washed. The collection efficiency of GSR from hands using a double-side adhesive has been studied (*532*). Neutron activation has been used to determine the antimony patterns around bullet entrance holes (*533*). Neutron activation has been shown to provide greater sensitivity in detecting trace elements as compared to energy-dispersive X-ray analysis when gunshot residue in the proximity of a bullet hole was examined (*534*). Atomic absorption spectrometry was used to determine trace elements in Winchester-Western cartridge case brass. It was determined that trace element analysis can serve as a basis for comparing cartridge cases (*535*). Various nitrated congeners of diphenylamine may serve to characterize a sample of gunpowder. These derivatives of diphenylamine may be isolated and identified by TLC and HPLC (*536*). The incidence of secondary transfer of gunshot primer particles to the hands is shown to be extremely low for a population of bow hunters (*537*). SEM combined with energy-dispersive X-ray analysis has been used to identify gunshot residue particles discharged by lead-free Sintex ammunition (*538*). A fluorescence method has been developed to detect ethyl centralite in gunshot residues (*539*). A review of the forensic aspects of gunpowder analysis has been undertaken (*540*).

Paint, Glass, Hairs, and Fibers. Microscopy and microchemical spot tests are effective tests for discriminating between automotive paints. Pyrolysis GC is a valuable discriminating technique (*541*). Fourier transform Raman spectroscopy is a very useful technique in automotive paint, coating, and polymer lens material characterization, as well as in paper analysis (*542*). Cathodoluminescence was applied to forensic paint identification using a light microscope or a scanning electron microscope (*543*).

The use of refractive index values after annealing to further discriminate glass samples may be considered unreliable at present (*544*). The temperature variation method was superior to the double variation method for glass refractive index determination (*545*). Trace elemental analysis of glass as applied to forensic analysis has been reviewed (*546*).

Scanning electron microscopy has been used to study pigment granules in the medulla of animal hairs (*547*). Mass spectrometric analysis was applied to the detection of dyes in human hair (*548*). Hair samples from outpatients of a methadone clinic were noted to have dark roots, which were opaque to transmitted light (*549*). It has been demonstrated that the microscopic comparison of Afro-Caribbean hair has forensic value (*550*). The stability of enzyme marker systems in human hair roots in a tropical environment was investigated (*551*).

Computer-based image processing has been applied to the surface imaging of animal fibers (*552*). GRIM 2 has been used to determine the refractive indexes of fiber (*553*). A series of experiments was performed to determine the level of secondary transfer of fibers via clothing and via seats (*554*). Forensic analysis of acrylic fibers by IR microscopy has been investigated. Preliminary results indicated that these type of fibers can be differentiated by manufacturer (*555*). HPLC using photodiode array detection has been applied to the analysis of dyes extracted from single fibers (*556*). HPLC was used for the analysis of dyes extracted from acrylic fibers (*557*). Characterization of acidic monoazo dyes using Euclidean distance measurements derived from HPLC detection has been reported (*558*). Dye analysis in forensic fiber comparisons has been reviewed (*559*). The collection of fiber evidence using water-soluble cellophane tape has been evaluated (*560*). It has been demonstrated that exposure

of clothing to wind and precipitation does not necessarily obliterate all transferred fiber evidence (*561*). Interpretation skills necessary to understand the significance of fiber evidence have been reviewed (*562*). The techniques used for the recovery, examination, and comparison of textile fibers in forensic science have been reviewed (*563*).

Fingerprints. Various commercially available alternate light sources have been compared and evaluated (*564*). The inherent UV fluorescence of fingerprints produces images with good ridge detail (*565*). 1,8-Diazafluoren-9-one (DFO) has been shown to be more sensitive than ninhydrin in developing latent fingerprints (*566*). Ten amino acid reagents were compared in their ability to visualize spots of amino acid glycine on paper (*567*). A one-step fluorescent cyanoacrylate fingerprint development technology has been developed. The technique involves using a heated "vapor wand" (*568*). Fluorescent dyes and cyanoacrylate fuming were shown to be a valuable combination for latent paint detection (*569*). Thenoyl–europium chelate produces brighter fluorescence when compared to similar prints developed with Ardrox and Rhodamine 6G (*570*). Thenoyl–europium chelate has been successfully used as a fluorescent dye in conjunction with cyanoacrylate-developed fingerprints (*571*). The application of europium luminescence to the visualization of cyanoacrylate-developed fingerprints is reported (*572*). The complexes Ruhemann's Purple formed with europium or terbium salts have been shown to be suitable for fingerprint development on strongly fluorescent surfaces (*573*). Luminescent lanthanide ions show emission enhancement when complexed with Ruhemann's Purple (*574*). Exposure of blood to cyanoacrylate fuming, argon ion laser, and alternate light sources does not effect the ability to type DNA (*575*). A new formulation similar to a small-particle reagent has been reported for latent fingerprint visualization on wet, dark objects (*576*). Different types of magnetic flake powders were produced for fingerprint detection purposes. These powders proved highly sensitive to latent fingerprints (*577*). A new powder metallurgy technique has made possible the development of improved fingerprint powders (*578*). Fourier transformation of an image and subsequent filtering in the frequency domain has been found to be an effective way to improve images of fingerprint marks (*579*). An efficient adaptive Fourier transform domain filter has been developed in order to enhance laser-luminescent fingerprints (*580*). Time-resolved luminescence imaging using a computer-interfaced gateable digital camera is shown to be useful for laser fingerprinting on strongly luminescent substances (*581*). Basic fuchsin has been successfully used to detect fingerprints on black electrical tape (*582*). Methyl red reagent has been successfully used to develop latent fingerprints (*583*).

Miscellaneous. Scanning TLC and reflectance microspectrophotometry have been applied to the comparison of similarly colored inks (*584*). A TLC procedure for examining the components of inks has been described (*585*). Techniques for determining the age of ball point inks have been suggested. Further work is necessary for testing the application of these techniques to ink dating (*586*). HPLC has been applied to the analysis of printing inks extracted from documents (*587*). IR spectroscopy has been used to identify and compare inks (*588*). Ball point inks were differentiated by IR spectroscopy (*589*). Two chromatographic methods for dating ball point inks have been evaluated (*590*). The application of the microdroplet method of X-ray analysis to the characterization of inks showed that ball point inks revealed no detectable elements (*591*). A simple method for analyzing photocopy toners by FT-IR has been described (*592*). Pyrolysis gas chromatography has been demonstrated to be a useful technique for the differentiation of photocopy toners (*593*).

A scheme based on dispersion staining was developed for the forensic examination of soil (*594*). The application of polarized microscopy to the forensic analysis of soils has been reviewed (*595*). A technique for comparing soil colors in forensic analysis has been described (*596*). Results reported suggest that inorganic analysis by XRF and multivariate analysis are useful to predict soil origins (*597*). The detection and persistence of glyoxylase isoenzymes in different types of soil has been investigated (*598*).

The effects of aging and weathering on the spectral and chromatographic characteristics of shoe polish marks on clothing were investigated (*599*). The chromatographic and spectral characteristics of shoe polish stains on white cotton fabric have been investigated (*600*). Physical methods for examining and comparing transparent plastic bags have been reviewed (*601*). Batches of polyethylene bags that differ slightly in color can be distinguished by X-ray fluorescence spectroscopy. Also, element profiles of colored polyethylene bags can be used for disguising different polyethylene bags (*602*). Elemental analysis by energy-dispersive X-ray fluorescence was used to characterize nail polish samples (*603*). TLC and colorimetry were used to differentiate similar shades of lipsticks (*604*). It has been demonstrated that erased numbers on polymers can be restored by taking advantage of polymeric thermal properties (*605*). Abrasive commercial toothpastes were studied and optical properties found useful for their identification were compiled (*606*). Metal particles produced by the cutting action of an abrasive disk were found to remain on clothing up to 17 h (*607*). Ammonium chloride as a fuming reagent has been used to reduce specular reflectance from metallic surfaces (*608*). A method for the discrimination of alumina ceramics was developed based on the observation of surface morphology, density, X-ray diffraction, and grain size distributions (*609*). Inductively coupled plasma-atomic emission spectrometry provides adequate element concentration determinations to achieve good discrimination of household aluminum foil (*610*). The measurement of lead isotope ratios can be combined with other methods such as trace element analysis to increase the possibility of differentiating between lead in bullets (*611*). Zircon has been found to be a useful reagent for the determination of the firing range of lead-free ammunition (*612*).

A TLC method for the identification of nonoxynol in contraceptive preparations has been developed (*613*). Pollen and spore contamination of illicit drugs can be used to establish background information on a drug's origin (*614*). A systematic evaluation of the effect of humidity on ESDA images was made (*615*). Stains of blood, semen, and saliva could be detected by their inherent UV luminescence (*616*). A pH pen was found useful when attempting to determine whether two paper products have a common origin (*617*). Rosin-based resins were characterized by pyrolysis and simultaneous pyrolysis methylation gas chromatography/mass spectrometry techniques (*618*). Results are presented for different chromatographic and mass spectrometric methods for the analysis of smoke dye in exploding money suitcases (*619*). Restoration of an obliterated message was accomplished with a personal computer. The document was scanned and the test made readable by performing image manipulations (*620*).

Reviews of the potential application of capillary electrophoresis to forensic science have been published (*621, 622*). Applications of liquid chromatography photodiode-array detection in forensic science have been reported (*623*). The use of inductively coupled plasma atomic emission spectrometry in forensic cases was described (*624*). A preliminary study has been conducted on the application of microscopical IR internal reflection spectroscopy for the analysis of forensic evidence. The technique shows great potential for the analysis of forensic evidence (*625*). The application of diffuse reflectance IR Fourier transform spectroscopy to forensic problems has been reviewed (*626*). Examples are given of the combined use of scanning electron microscopy and polarized light microscopy to solving forensic problems (*627*). The application of hard X-rays to forensic science problems has been reviewed (*628*). The use of soft X-rays in forensic science has been reviewed (*629*). A statistical evaluation of the significance of crime scene evidence has been undertaken (*630*). The evidential value of trace evidence was statistically assessed (*631*). A Bayesian approach to assessing the value of crime scene evidence has been reported (*632*).

FORENSIC BIOCHEMISTRY

An historical review of the characterization of blood and secretion stains in the forensic science laboratory has been published (*633*). The Heme Select test was found to be a suitable blood test to determine the species of origin of unknown stains (*634*). The Takayama crystal test has been modified to make it a faster test for confirming blood (*635*). Species identification from tissue particles using lectin and immunohistochemical techniques has been reviewed (*636*). Detection of the ABO blood group in hair under different environmental conditions has been explored (*637*). The effect of fabric substrates on ABO agglutination was examined (*638*). The specificity differences among various anti-H reagents against red cells, blood, saliva, and hair have been investigated (*639*). Monoclonal and polyclonal antibodies were compared for typing ABO blood groups (*640*). Monoclonal antibodies have been used to type ABH and Lewis blood group antigens in blood and saliva (*641*). The ability of enzyme-linked immunosorbent assay (ELISA) to detect Lewis and H antigens from autopsy specimens was assessed (*642*). Commercial monoclonal reagents has been evaluated for the ABO typing of blood (*643*). The effect of sodium fluoride on ABO, phosphoglucomutase (PGM), and erythrocyte acid phosphatase (EAP) typing of blood samples has been investigated (*644*). Efficient methods for the production of monoclonal antibodies for forensic application have been reported (*645*). Genetic and molecular aspects of human red cell acid phosphatase have been described (*646*). Rare variants of PGM and EAP have been encountered in casework (*647*). The possibility that pollen grains can interfere with PGM phenotyping has been investigated (*648*). A quick and sensitive technique to subtype group-specific component (Gc) and esterase D (EsD) simultaneously has been reported (*649*). Esterase D variants in the Spanish population have been reported (*650*). Stains of normal and menstrual blood have been analyzed for glyoxylase-I (GLO-I) and ABO antigens from the same cloth (*651*). Several modifications have been made to a system capable of the simultaneous phenotyping of EAP, EsD, PGM, and adenosine deaminase (ADA) in bloodstains by isoelectric focusing (*652*). Allelic frequencies for transferrin (Tf) EAP, EsD, and Gc have been reported (*653*). Immunofixation and immunoblotting techniques for subtyping Gc in aged blood and semen stains have been compared (*654*). Subtyping Gc in stains by isoelectric focusing has been shown to be promising (*655*). A method for the simultaneous determination of Gc and α-HS-glycoprotein has been reported (*656*). Gene frequencies of ApoB alleles in the Italian population have been reported (*657*). Hemoglobin extracted from bloodstains was investigated using cation-exchange HPLC. A possible application with respect to determining the age of a stain was explored (*658*). HPLC analysis of hemoglobin in bloodstains has been found to be useful for the differentiation of human and animal bloodstains (*659*). Haptoglobin subtyping of bloodstains by polyacrylamide gel isoelectric focusing was investigated (*660*). The detectability of haptoglobin in bloodstains as a function of age and temperature was studied (*661*). Frequencies of haptoglobin subtypes in Germany have been reported (*662*). Hemoglobin alleles were identified by isoelectric focusing (*663*). A semiautomated method for phenotyping α-2-HS-glycoprotein has been published (*664*). A microplate-based dot blot immunoassay for the detection of HLA antigens in bloodstains was reported (*665*). Genotype frequencies of HLA class II genes were determined in the Swedish population (*666*). A pregnancy protein, SP 1, has been detected in bloodstains (*667*). Serum proteins in bloodstain were typed by isoelectric focusing (*668*). Techniques for determining the sex origin of body fluids and stains have been reviewed (*669*). Menstrual bloodstains were differentiated from peripheral bloodstains based on the lactate dehydrogenase isoenzyme pattern (*670*).

A method for the detection of prostate-specific antigen (P-30) by ELISA has been developed (*671*). In vaginal washings from rape victims, more positive results were detected for acid phosphatase than prostate-specific antigen (*672*). The evaluation of lactate dehydrogenase isoenzyme as an approach for semen detection has been discussed (*673*). Monoclonal antibodies has been used to type ABO blood groups in mixed body fluids of saliva, semen, and vaginal secretions (*674*). Results indicate that monoclonal antibodies specific for 8-glutamyl transpepidase might contribute to the detection of seminal samples (*675*). A new dot-immunobinding method was developed for the detection of human seminal plasma antigens (*676*). The enzymatic activity of γ-glutamyl transferase (*GGT*) was found to the most informative parameter as to the age of semen stains (*677*). The enzyme deoxyribonuclease I (DNase I) has been applied to the individualization of semen (*678*). A sensitive and specific dot blot immunoassay based on prostate-specific antigen was developed for detection of trace amounts of human semen in stains (*679*). A sandwich enzyme immunoassay has been used to detect γ-seminoprotein and β-microseminoprotein. These proteins are useful for confirming the presence of semen (*680*). Results of amylase tests performed on more than 400 casework swabs have been reported (*681*). Polymorphisms of salivary proteins and enzymes and their application to forensic science have been reviewed (*682*). A radial diffusion assay utilizing crude kidney bean extract and α-amylase inhibitor isolated from wheat was assessed to differentiate α-amylase from various sources (*683*). An absorption inhibition procedure was found to reliably detect ABO antigens in teeth (*684*). Studies on the persistence of genetic markers in teeth stored at room temperature showed that ABO blood groups were most stable whereas carbonic anhydrase isoenzymes were the least stable (*685*). Serum transferrin subtypes have been found

in dental pulps (*686*). The determination of polymorphic enzymes from dental pulp has been described (*687*). The stability of PGM and Gc in urine was studied. PGM could be detected up to 1 week and in some cases up to 1 month in urine stored at 4 °C (*688*).

A quality assurance program for a forensic biology laboratory is discussed in terms of development and implementation (*689*). Restriction fragment length polymorphisms (RFLP) allele sizes were not significantly affected by environmental conditions or contamination factors (*690*). It has been demonstrated that some of the *Hae*II-digested DNA fragments are small enough to prevent their reliable sizing on a Southern blot (*691*). The influence of agarose concentration and electric field strength on the separation of DNA fragments during electrophoresis has been investigated (*692*). An evaluation of the merits of common DNA extraction methods has been undertaken (*693*). The effects of various tissue fixatives and fixation times on DNA extractability have been determined (*694*). Sonication procedures for the extraction of DNA from semen specimens were developed (*695*). Chelating resins have been shown to prevent the degradation of DNA during its extraction (*696*). Various methods for accomplishing Southern blotting have been compared (*697*). Contact printing of silver-stained gels on standard X-ray film provides a rapid and sensitive means for reproducing allelic profiles (*698*). A computer-aided fragment size determination of single-locus DNA probes has been reported (*699*). DNA typing using single-locus probes and experiences with a computerized database have been described (*700*). The effects of using different molecular weight markers in DNA typing have been investigated (*701*). Multilocus DNA probes have been used to link animal remains to blood and tissue samples recovered from individuals accused of violating hunting regulations (*702*). DNA typing using a solid-phase minisequence method has been reported (*703*). The fixed bin method has been shown to provide a robust and conservative estimated for RFLP profile relative to the floating bin and direct count methods (*704*). The use of chemiluminescent probes has been investigated. In general, their sensitivity is equal to or better than radioactive probes (*705*). Methods for the synthesis, purification, and quantification of fluorescent labeled probes have been described (*706*).

Different matching criteria in RFLP analysis of stains have been evaluated (*707*). An allele with an internal *Hinf*I restriction site has been found in the D12SII locus (*708*). A gel filtration technique for purifying degraded DNA in forensic specimen extracts was investigated (*709*). RFLP analysis of the probes MS1, MS31, MS43a, and YNH24 has been carried out in the Danish population (*710*). Frequency distribution of DSS44, DSS43, D7S21, D7S22, and D12S11 in the Turkish population has been reported (*711*). Frequency distribution of D2S44 α-globin 3′ HVR and D12S11 has been studied in the Italian population (*712*). Allele frequency distribution of D2S44 and α-globin 3′ HVR were investigated in parts of Italy (*713*). RFLP frequencies for YNH24 in an Italian population have been reported (*714*). Italian population frequency data have been reported for D1S80 (*715*). Allele frequency data for D17S79 for the black population of southern Ontario, Canada, were reported (*716*). RFLP profiles for D2S44, D10S28, D4S139, and D1S7 were obtained for Chinese, Malaysian, and Indian population groups (*717*). Frequency databases have been reported for the DNA probes MS1, MS31, MS43A, and YNH24 (*718*). Allele frequencies for five different single-locus probes were determined for the population of southwest Germany (*719*). Population genetic studies in Australian Aborigine, American black, Chinese, Caucasian, and American Indian populations were performed with several highly polymorphic DNA loci (*720*). It has been demonstrated that estimated DNA profile frequencies developed from RFLP analysis differ more between than within major population groups (*721*). A discussion of the statistical aspects of the National Research Councils Report on DNA typing has been published (*722*). *Hinf*I-generated RFLP profile frequencies were determined using various ethnic databases (*723*). Frequency estimates of a variable number of tandem repeats (*VNTR*) loci demonstrate that major population groups can be used to provide estimates of DNA profile frequencies without consequence of a wrongful bias (*724*). Comparisons across major population groups provide reasonable, reliable, and meaningful estimates of DNA profile frequencies (*725*). DNA typing results were examined and compared for six German forensic laboratories (*726*). Intralaboratory size calculations of restriction fragments revealed good reproducibility of fragment size measurements in each laboratory (*727*). Interlaboratory comparisons of autoradiographic DNA RFLP band size measurements were reported. Adequate interlaboratory consistency was achieved (*728*). Statistical and population genetic issues involved in calculating the frequency of a DNA in a criminal case have been reviewed (*729*). A new approach to RFLP probability calculation has been proposed (*730*). A method for calculating the probability of a DNA match that does not require the assumption of independence was presented (*731*). The effect of relatives on the likelihood ratio associated with DNA evidence has been explored (*732*). The likelihood ratio approach for DNA typing in criminal cases has been described (*733*).

Highly repetitive DNA markers have been used for determining the species origin of animal tissues in cases of illegal commercialization and poaching of game animals (*734*). Sex typing of forensic DNA samples was accomplished using male- and female-specific probes (*735*). Several methods for sex determination of human DNA have been developed focusing on detection of the Y-specific chromosome (*736*). DNA sequence analysis of an amplified portion of mitochondrial DNA was successfully performed on human skeletal remains (*737*). The sequencing method of the D loop region of cloned mitochondrial DNA was applied to human identification (*738*). Minisatellite variant repeat (MVR) PCR has been successfully used to determine the source of saliva on a postage stamp (*739*). A minisatellite probe, M21.3, has been used to produce highly informative fingerprints from human DNA (*740*). A review of progress in DNA typing by minisatellite variant repeat mapping has been reported (*741*). Digital DNA type of the highly polymorphic minisatellite MS31A by minisatellite variant repeat mapping has been reported (*742*). It has been demonstrated the MVR-PCR can be applied to practical forensic samples (*743*). Typing of the D1S80 locus using the MVR-PCR method was performed (*744*). Minisatellite variant repeat mapping by PCR provides a digital approach to DNA typing (*745*). Increased discrimination of digital DNA typing by the simultaneous analysis of two polymorphic sites within minisatellite variant repeats at D1S8 has been reported (*746*).

The application of capillary electrophoresis to the forensic characterization of DNA has been described (*747*). A method has successfully been developed for cloning hyperviable DNA by

constructing charomid libraries (*748*). Findings indicate that mutation might be a basis for the evolutionary expansion of VNTR fragment length (*749*). Tandem repeat internal mapping and DNA sequencing of the human involucrin gene has been reported (*750*). Extracts of bloodstains have been applied to a synthetic porous membrane and treated with appropriate reagents to produce a rapid dot blot method for species identification (*751*). DNA analysis of human bone and soft tissues has been reviewed (*752*). It has been reported that flow cytometry can be used in place of gel electrophoresis to detect the presence of high molecular weight DNA in decomposed tissues (*753*). The utility of RFLP analysis of DNA in criminal cases has been described (*754*). The administration of the topical anti-HIV agent nonoxinol-9 is not an impediment for obtaining DNA profiles from vaginal swabs (*755*). Postmortem tissues such as blood and kidney were found to be unsuitable for DNA fingerprinting because of a rapid degradation of the DNA after a period of 1 week (*756*). DNA probes commonly used for forensic profiling analysis were found to be specific and failed to identify any microbial DNA sequences (*757*). The application of serological and DNA methods for the identification of urine specimen donors has been reviewed (*758*). RNA was successfully extracted from postmortem tissues and used for the amplification of DNA sequences (*759*). RFLP analyses was performed on condoms in order to determine the order of sexual assaults (*760*).

A comprehensive study provides support that the HLA-DQ α PCR procedure is valid for typing forensic samples (*761*). The amplitype PM PCR amplification and typing kit has been favorably evaluated (*762*). PCR-HLA DQ α-analysis has been found to be a more suitable method than RFLP in the identity determination of urine samples (*763*). Problems connected with sensitive PCR approaches to the typing of DNA in forensic specimens have been described (*764*). Validation experiments were performed to evaluate the HLA-DQ α PCR typing system for forensic casework (*765*). The addition of bovine serum albumin can decrease problems associated with the inhibition of PCR amplification (*766*). DNA extracted from putrefied tissue or bloodstains sometimes contains the contaminant identified as hematin. When performing PCR it is necessary to eliminate this contaminant (*767*). DNA from bloodstains aged up to 1 year could be sufficiently amplified if salmon sperm DNA was added to the DNA solution medium (*768*). Nine DNA extraction methods have been evaluated for their effectiveness in yielding DNA suitable for amplified fragment length polymorphism (AMP-FLP) analysis (*769*). DNA recovered from formalin-fixed tissue has been characterized through PCR amplification (*770*). Possible approaches for validating amplified fragment length polymorphism determinations have been proposed (*771*). DNA extracted from human nail clippings has been typed by HLA-DQ α (*772*). Analysis for Y-chromosome-specific DNA sequences by PCR can be used to determine the sex of donors of biological samples (*773*). A rapid, simple, and reliable sex test that entails PCR amplification of a segment of the X–Y homologous gene amelogenin has been developed (*774*). A study of sex determination from bloodstains by PCR was reported. Sequences of the Y and X chromosome were specifically amplified (*775*). PCR results were obtained from 2 year old paraffin-embedded muscle and heart blocks (*776*). A method for determining the ABO genotype directly from human DNA using multiplex PCR and restriction enzyme analysis has been developed (*777*). Fluorescently labeled PCR primers were used to amplify genomic DNA of three different VNTR sites (*778*). Fluorescent tagging of PCR products coupled with detection by laser scanning during electrophoresis was used to automate VNTR/short tandem repeat (STR) characterizations (*779*). DQ α allele and genotype frequencies have been determining for the Florida population (*780*). Allele frequency for HLA-DQ α in the Spanish population has been reported (*781*). HLA-DQ α and DQ β allelic frequencies were determined in the Swedish population (*782*). Allele frequencies of HLA-DQ α and HLA-DP β in the Japanese population have been reported (*783*). The distribution of the D1S80 alleles was determined by AMP-FLP analysis in the Singapore population (*784*). Population data have been published for three different AMP-FLP systems in a German population (*785*). Frequency data for D1S80 amplified by PCR and analyzed by AMP-FLP have been reported for the Danish population (*786*). The hypervariable locus D17S5 was examined in four ethnically defined populations to compare the efficiency and limitation of Southern blot analysis and PCR and to provide allele frequency data (*787*).

Alu-PCR was used to amplify human DNA from mixed sources of DNA (*788*). A technique in which individual, amplified alleles are isolated combined, and amplified by PCR to produce a functional reference ladder has been described (*789*). The contribution of the DX α DNA sequences to the low-level hybridization signal that is sometimes detected in the 1.1 probe sequence of the DQ α amplitype typing strip has been investigated (*790*). PCR of the D17S30 locus was not recommended for forensic practice (*791*). A contaminant likely to be the heme–blood protein complex has been studied with regard to its inhibition of PCR (*792*). DQ α 4 alleles can be distinguished by restriction analysis of the PCR product (*793*). It has been demonstrated that amelogenin PCR products migrate anomalously using nondenaturing polyacrylamide gel electrophoresis as opposed to agarose gel electrophoresis or denaturing PAGE (*794*). PCR amplification of several polymorphic VNTR regions has been described (*795*). Human identification by use of PCR and direct sequencing has been discussed (*796*). A random amplified polymorphic DNA method was used to identify the species of a forensic biological sample (*797*). PCR analysis was used to differentiate the origin of decomposed bovine meat (*798*). The possibility of HLA-class II genotyping for DNA extracted from hairs, blood, and teeth using PCR has been investigated (*799*). DNA extracted from old formalin-fixed, paraffin-embedded tissues was amplified and typed using PCR and RFLP (*800*). HLA-DP β polymorphism was analyzed from single hairs as was the HLA-DQ β polymorphism (*801*). PCR has been successfully used to characterize DNA recovered from burned fire victims (*802*). Amplified fragment length polymorphisms have been shown to be powerful tools for characterizing degraded DNA (*803*). The utility and reliability of DNA amplification for forensic DNA samples was tested using material previously analyzed by RFLP. Approximately half of the sample that did not yield RFLP results produced interpretable data using AMP-FLP (*804*). Specific insect DNA fragments were amplified and sequenced in order to identify insect species used for postmortem interval estimation (*805*). Results indicated that DNA can be extracted and amplified from 125 year old bone without decalcification (*806*). The automation of the amplification and sequencing of mitochondrial DNA has been described (*807*).

An automated fluorescent-based system was used to investigate the typing of two tetrameric STRs in the Swedish population (*808*).

Automated fluorescence-based technology was used to detect amplified STR loci electrophoresis on polyacrylamide (*809*). An automated approach to DNA typing of STR systems was evaluated using the Gene Scanner (*810*). The multiplex analysis of short repetitive DNA sequences by automated fluorescent detection has been described (*811*). Analysis of the STR HUMVWA in the Spanish population has been reported (*812*). The frequency of the STR HUMVWA31A was studied in the British Caucasian population (*813*). Allele frequencies for the STR loci HUMTH01 has been evaluated in a Spanish population (*814*). Frequencies of the STR locus HUMTH01 have been calculated in the English and Spanish populations (*815*). The STR system HUMTH01 was analyzed in the Danish and Eskimo populations (*816*). Using PCR, the frequency of three STRs was investigated in five populations (*817*). The amplified product of 44 STR alleles at the D11SS54 locus has been sequenced (*818*). A collaborative exercise intended to demonstrate whether uniformity of DNA typing results could be achieved between European laboratories using STR loci has been reported (*819*). The application of STR to forensic analysis has been presented (*820*). In vitro amplification of alphoid repeated sequences by PCR in aged tissue samples was carried out for the purpose of sex identification (*821*). The application of PCR technology to forensic science has been described (*822*). DNA typing has been reviewed (*823*). Multiplex PCR was used to amplify six VNTR loci when coupled with fluorescent detection. This approach yielded a highly discriminating automated test (*824*). The coupling of a chemiluminescence detection system allows for the direct sequencing of PCR products (*825*). A capillary electrophoresis system has been developed which has the ability to rapidly analyze DNA restriction fragments and PCR products (*826*). Capillary electrophoresis was performed on PCR-amplified DNA using fluorescence detection with an intercalating dye (*827*). Results show that PCR amplification of a genome sequence is possible in human bones 100 years old (*828*). A new method for forensic identification of individuals was developed where a panel of biallelic DNA markers is amplified by PCR and the variable nucleotides are detected in the amplified DNA fragment (*829*). The use of PCR technology in forensic science has been reviewed (*830, 831*). It was determined that samples could be processed for latent prints and ESDA examinations and still yield sufficient DNA for DQ α PCR typing results (*832*).

BOOKS

There have been some noteworthy books published on forensic science topics since 1992. *DNA Fingerprinting* (*833*) and *DNA in the Courtroom, A Trial Watcher's Guide* (*834*) are two excellent introductory books on the subject of forensic DNA analysis. *Forensic Application of Mass Spectrometry* (*835*) provides an excellent in-depth treatment of forensic mass spectrometry analysis. *Criminalistics—An Introduction to Forensic Science* (*836*) is the 5th edition of a popular introductory text. *Forensic Science Handbook: Volume III* (*837*) continues a series of books detailing practices of forensic science. FBI symposium proceedings are contained within *Proceeding of the International Symposium on the Forensic Aspects of Mass Disasters and Crime Scene Reconstruction* (*838*) and *Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence* (*839*). *Advances in Analysis and Detection of Explosives* (*840*) contains the proceedings of the 4th International Symposium on Analysis and Detection of Explosives. The excellent book *Spitz and Fisher's Medicolegal Investigation of Death* (*841*) has been updated, as has the widely circulated toxicology reference book *Disposition of Toxic Drugs and Chemicals in Man* (*842*). Applications of chromatography to forensic science are extensively covered in *Toxicological and Forensic Applications of Chromatography* (*843*).

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