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THE FORENSIC SCIENCES FOUNDATION, INC.

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FORENSIC MICROSCOPY WORKSHOPS

Final Report

78NI-AX-0066

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Final Report

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ABSTRACT

The Forensic Microscopy Workshops project was designed to conduct 20 one-week regional workshops in forensic microscopy for approximately 300 crime laboratory examiners. Training was provided for 357 examiners, exceeding the project goal by 10%. A review of the state of the art of forensic microscopy and a model for future criminalistic workshops were also accomplished during this program.

Priority topics for future training workshops were compiled, based on a survey of workshop participants. The mean rating from student evaluations of the value of the course was 6.0 out of 7.

The study has identified a nucleus of dedicated and highly motivated examiners who should be given additional training in forensic microscopy. Recommendations for the continuation of training opportunities and the establishment of mechanisms to continue to update the skills of workshop graduates in forensic microscopy are contained in the final report.

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FORENSIC MICROSCOPY WORKSHOP
STEERING COMMITTEE MEMBERS

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George Ishii
Western Washington Regional Crime Laboratory

Peter R. De Forest
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We are grateful to the many regional site coordinators for their on-site assistance, to the regional forensic sciences associations for their cooperation in promoting these workshops, and to the crime laboratory directors and examiners for allowing the use of their training centers and for their overwhelming support for this training venture.

We wish to thank John O. Sullivan, NILECJ Project Monitor, for his recognition of the need for these workshops and for his perserverance in furthering the goal of upgrading the quality of the forensic sciences in the nation's crime laboratories.

EXECUTIVE SUMMARY

A. Introduction

The Forensic Microscopy Workshops Project has resulted in the training of more than 300 examiners from 177 of the nation's crime laboratories. Three main factors were responsible for the successful completion of this project: (1) the expertise and teaching ability of the McCrone Research Institute (McRI) instructional staff, (2) the proximity of the training workshops to those examiners receiving the training, and (3) an 80% reduction in the workshop fee, which otherwise would have been prohibitive for most crime laboratories and individual examiners.

The function of the crime laboratory is to bring scientific methods and knowledge to bear on the criminal justice system. Among the types of physical evidence routinely analyzed by examiners are: firearms and ammunition; bloodstains; questioned documents; latent fingerprints; drugs and narcotics; body tissue; and various other trace materials. Microscopic analysis is particularly suitable for the examination of trace evidence such as glass, paints, soils, botanicals, fibers, hair, drugs, explosives and gunshot residue. However, if the laboratory is to benefit from the services that microscopy can offer, examiners must be adquately trained. Unfortunately, this is not usually the case. Inadequate exposure to the microscope, lack of qualified instructors and budget cuts which limit opportunities for training are among the factors that contribute to the disuse of microscopy in crime laboratories. The results of the Forensic Sciences Foundation's <u>Laboratory Proficiency Testing Research Program</u> (LEAA Grant Nos. 74NI-99-0048 and 76NI-99-0091) demonstrated that laboratories were experiencing difficulties in the examination of many types of trace evidence which require the proper use of the microscope such as glass, hair, fibers, paint, soils, drugs, wood, paper and firearms.

B. Methodology

The initial task of the project was to select a Workshop Steering Committee (WSC) to be responsible for overall project guidance and internal evaluation. Those selected were:

Harold A. Deadman
Laboratory
Federal Bureau of Investigation
Washington, D.C.

Peter R. De Forest
John Jay College of Criminal Justice
New York, New York

Bart Epstein
Minnesota Bureau of Criminal Apprehension
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Dale H. Heideman
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Tallahassee, Florida

George Ishii
Western Washington Regional Crime Laboratory
Seattle, Washington

Walter C. McCrone
McCrone Research Institute
Chicago, Illinois

John I. Thornton
School of Public Health
University of California
Berkeley, California

The McRI instructional staff developed the curriculum for the workshops. It was modified to meet the needs of each regional workshop, to correspond to the equipment capabilities of crime laboratories in these regions and to reflect the results of the proficiency testing research project. Minimum laboratory and student eligibility requirements for admission to the workshop were developed by the WSC and implemented by Forensic Science Foundation (FSF) staff. FSF also administered the student application procedure.

Twenty forensic microscopy workshops were conducted in the following locations:

Orlando, Florida	London, Ohio
Atlanta, Georgia	Denver, Colorado
Raleigh, North Carolina	Seattle, Washington
Washington, D.C.	Modesto, California
Storrs, Connecticut	Los Angeles, California
Chicago, Illinois	Phoenix, Arizona
Austin, Texas	Shreveport, Louisiana

Baltimore, Maryland

Fifteen workshops were at a basic level of difficulty and five were advanced courses in either Botanicals or Soils and Mineralogy.

All supplies and materials were provided and transported to each workshop site by McRI. These materials included 25 polarizing microscopes and supporting materials, a closed circuit TV system, a public address system, AV equipment, laboratory chemicals and supplies and a library.

A workshop evaluation component was built into the project, comprising pre- and post-workshop evaluations of students' knowledge, daily quizzes, practical examinations, follow-up proficiency testing and student assessments of the training program.

C. Results

1. Enrollment. The forensic microscopy workshop resulted in the training of 357 scientists, exceeding by 57 (19%) its stated goal. The mean number of students per class was 17.9. An average of 9 crime laboratories were represented at each workshop - a total of 177 in all.

2. Proficiency Tests. Over half the students who attended the basic courses reported their follow-up proficiency test results to McRI. Sixty-four percent have completed their tests satisfactorily and 35% are in various stages of retesting. No student has failed the retesting.

All students who completed the advanced courses passed the proficiency tests administered during the workshops and received certificates of completion. Considering both the basic and advanced workshops, 75% (167) of the 223 participating students successfully completed their proficiency tests.

3. Student evaluations. Using a standard 7-point response scale ranging from low or poor (1 through 3), to neutral (4), to good or positive (5 through 7), students were asked to rate the workshops on various criteria. The overall value of the workshops was rated at 6.0; the quality of the instruction was 6.4; instructors' skill 6.9; instructors' knowledge of forensic microscopy 6.8, to highlight a few items. Of the workshops' participants, 98.2% indicated they would recommend these courses to others from their home laboratories. When asked to recommend topics for future training workshops, fibers, hair, soils/mineralogy, paint and drugs were mentioned most frequently.

4. Microscope slide sets. A set of approximately 80 standard reference microscope slides was issued to each laboratory that sent a student to each workshop.

5. Future workshops model. Guidelines for those planning to offer training workshops in the future were compiled by project staff into a "Future Workshops Model." The model includes the project's recommendations for selection of instructional staff, the use of advisory boards, determination of class size and length, site selection, setting tuition, advertising, application and workshop evaluation procedures.

6. State-of-the-art monograph. The project has produced a monograph entitled, "A Summary of the State of the Art of Forensic Microscopy."

D. Findings and Recommendations

Scientists of varying experiences and motivations attended these workshops. Many saw the course as a unique opportunity to advance their forensic capabilities through an intense one-week effort with one of the world's most

gifted microscopists. Many students made an effort to derive maximum benefit from the course, devoting many hours to studying on site and to follow-up proficiency testing and further learning on returning to their home laboratories. Others were content to pick up a few "tricks" to utilize in the laboratory. A veteran police officer who described the course as his "most intense experience since SWAT training" most clearly captured the intensity of the workshop, a feeling shared by most of his fellow participants.

As a result of these workshops, there is evidence of unprecedented interest in forensic microscopy by criminalists. Some regional forensic science associations have contacted the workshop teaching staff hoping to schedule additional local workshops for their criminalists. An informal newsletter to discuss topics relating to forensic microscopy is soon to be published. McRI staff often is consulted by workshop graduates concerning problems encountered on specific cases and on how to expand laboratory standard reference materials. Students boast of successful analyses of trace evidence using the microscope that they would never have attempted before taking the workshops.

Despite these accomplishments, one or two-week intensive courses in forensic microscopy cannot transform the criminalist into an accomplished forensic microscopist or cause a dramatic immediate nationwide increase in the use of forensic microscopy. What was accomplished at this series of workshops, however, was to heighten the examiners' awareness of the many capabilities and applications of the polarizing microscope to solve problems associated with physical evidence. Basic procedures were presented and demonstrated with the hope that, on returning to his or her home laboratory, the student would practice these skills to attain an even higher level of competency.

The momentum generated by the Forensic Microscopy Workshops should be sustained through the support of additional training workshops. This model of regionally based workshops has proved quite effective and would lend itself to continued training schedules for both introductory and special-topic presentations. Suggestions from laboratory directors and students point to the need to support a major portion of student travel and living expenses for future workshops, in addition to the basic cost of tuition. This arrangement, which proved successful for other NILECJ funded training workshops, would permit smaller outlying laboratories to send their personnel to the workshops and would increase the overall level of participation nationwide. Funding for 80% of student travel and living expenses is thus strongly recommended.

It is imperative that participants in these workshops be afforded the opportunity to continue training in forensic microscopy. Thus we recommend that programs be supported - - perhaps in conjunction with regional forensic science association meetings and/or the annual meeting of the American Acadmy of Forensic Sciences - - to provide periodic update workshops and common-interest sessions for forensic microscopists. Internships and sabbaticals are required to further develop the skills of crime laboratory personnel and allow them opportunities to put aside their casework and pursue research in forensic microscopy. A survey to identify microscopy programs at colleges and universities should also be undertaken, and the better programs supported through student scholarships, internships, and continuing programs to bring faculty up to date in current technology.

Consensus of the project staff, instructors, steering committee and students is that the length of the basic workshop should be lengthened to two weeks. Although this would require a corresponding increase in tuition and other expense, it is deemed necessary. The one-week, advanced, special topic courses which would be offered to each region during the proposed second phase of

training, should continue unchanged. Topics for advanced courses should include botanicals, soils, and explosives and explosive residues. A drug identification course is also badly needed but would require at least a year to prepare. An estimated budget for offering twenty additional basic and advanced workshops is included in the project final report. A proposal for a course in forensic microscopy for occasional users is also recommended.

CHAPTER I. INTRODUCTION

The NILECJ-sponsored Forensic Microscopy Workshops Project has resulted in immediate and tangible benefits for the nation's crime laboratories. A substantial number of scientific examiners have measurably improved their ability to examine physical trace evidence using the polarizing microscope. Through this series of regional workshops, microscopy training has been offered to over 300 examiners, representing 177 out of the approximately 250 crime laboratories in the United States --- a major accomplishment.

A. Success Factors

Three main factors were responsible for the successful completion of this project: (1) the expertise and teaching ability of the McCrone Research Institute instructional staff, (2) the proximity of the training workshops to those examiners receiving the training, and (3) an 80% reduction in the workshop fee, which otherwise would have been prohibitive for most crime laboratories and individual examiners.

1. Quality of training. We were fortunate to have the instructional services of the McCrone Research Institute (McRI), which is considered to be one of the most competent scientific laboratories in the fields of microscopy, ultramicroanalysis, and crystallography. The McRI staff was directed by Dr. Walter C. McCrone, the founder and chief scientific advisor of McCrone Associates, and by Mr. Skip Palenik, teacher, scientist, and recognized expert in the area of forensic microscopy. They provided the strongest foundation for a training program of this magnitude; this is apparent from the students' evaluations discussed in Chapter III.

2. Workshop availability. Efforts to attract substantial numbers of laboratory examiners to training workshops are usually hindered by the budget restrictions and the backlog of cases in the examiner's home laboratory.

Tuition expenses for a typical training course often exceed $500 per week, which combined with airfare, ground transportation, and living expenses limits the number of students that a laboratory director can afford to send to a typical, centrally located training program.

We solved this problem successfully in this training project because we were able to reduce training costs by transporting the teachers and the instructional materials to various regions of the nation. Twenty regional forensic microscopy workshops were conducted in the continental United States, each capable of accommodating up to 24 microscopists. All equipment and supplies were transported by van to those geographical regions of the country where the greatest demand and need for training existed. The equipment and supplies included 25 polarizing microscopes, a closed-circuit video system, assorted audio-visual and laboratory materials, and a library of general science and forensic science literature.

3. Cost of training. Through the support from this NILECJ project, the cost for each student was $65 for a one-week session. The cost of the student's course manual and laboratory supplies were included in this nominal charge. Students, or their laboratories, were required to pay for their transportation and living expenses; these costs were minimized when possible by obtaining dormitory space in universities or police department training facilities or by arranging for special group rates at commerical hotels or motels.

B. Need for Training

Function of the crime laboratory. The function of the crime laboratory is to bring scientific methods and knowledge to bear on the criminal justice system. Techniques adopted from the biological, chemical, and physical sciences are combined to produce information for judicial decision-makers, giving them a powerful means for resolving questions surrounding a legal case --- ultimately the guilt or innocense of the accused.

The analytical techniques of the forensic laboratory are important to all aspects of the criminal justice system. The forensic scientist my help determine whether a crime has been committed, for example, in determining the origin and cause of suspicious fires or in resolving questions about a death that might have resulted from an accident, foul play, or suicide. The crime laboratory is called on both to aid the police in the identification of suspects in criminal investigations and to answer inquiries that might clear an innocent person. Many crime laboratory examinations culminate in the presentation of facts in a court of law by the expert witness.

C. Examination of Evidence Using Microscopy

Types of physical evidence routinely examined by crime laboratory examiners include a wide range of categories: firearms and ammunition; bloodstains; questioned documents; latent fingerprints; suspected drugs and narcotics; body tissue (toxicology and pathology); and various other trace materials (Figure 1). Microscopic analysis is particularly suitable for trace evidence such as glass, paints, soils, botanicals, fibers, hair, drugs, explosives, and gunshot residue. Only a very small percentage of potential trace evidence at crime scenes and on victims is collected. Of this, only a small fraction is analyzed. Many times, microscopy is the only method suitable for this analysis.

In the hands of a skilled forensic examiner, the microscope frequently limits the need for other, more costly, sophisticated examination techniques and instrumentation in the crime laboratory while delivering an equal or greater amount of useful information. Both initial costs and maintenance costs of the microscope are low. Because budget cuts are likely to continue

FIGURE 1

STUDENT AT MICROSCOPE

in most police agencies and forensic laboratories, there may be a move away from expensive instrumentation and toward the more economical, equally effective microscope. However, if the laboratory is to benefit from the services that microscopy can offer, examiners must be adequately trained.

D. Reasons for the Inadequate Use of Microscopy

Laboratory personnel generally have been unaware of the extensive forensic analytical capabilities of the microscope. Microscopy is seldom offered as a separate course in the scientific curriculum of most colleges and universities. Students acquire only cursory knowledge of and limited familiarity with the microscope in their general science course work. Furthermore, it takes a considerable investment of time and money to train a person to become a qualified microscopist. Rather than making this investment or hiring a trained microscopist, laboratory directors have often used federal funds to buy costly and "impressive" instrumentation that, although unquestionably useful in certain types of analyses, has fewer applications than does the microscope.

Consequently, few truly qualified microscopists can be found in the nation's crime laboratories. In addition to the reasons stated above, other factors have discouraged using the microscope to derive its full potential as a forensic analytical tool. One important reason is that it is less time-consuming to train scientists to operate many of the sophisticated, automated instruments than it is to train them in the relatively complex theory and use of the microscope. To become a microscopist, one must also understand illumination, optics, filters, specimen preparation, optical crystallography, and photomicrography.

Another important reason for the lack of qualified microscopists stems from the dramatic increase in laboratory case loads in the 1960s and early 1970s,

which resulted from the enormous influx of drug-related cases. (To successfully bring charges against a suspected drug offender, the state is required to prove that the confiscated materials are contraband, and thus, illegally possessed by the suspect.) Although laboratory budgets tended to increase during this time, their case loads generally increased faster. Thus, many laboratories experienced a net decrease in the ratio of available resources to the volume of cases handled, even though their total budgets had increased. Accordingly, some laboratory directors became reluctant to allow their personnel the time away from the laboratory to attend training courses in microscopy as well as in other areas of the forensic sciences.

Those laboratory directors who recognized the need for training in microscopy seldom were able to find qualified instructors who could offer this training at a reasonable cost. They were forced to rely on in-house, on-the-job training, which was often difficult to formalize and usually proved to be of less than optimal effectiveness. Furthermore, many laboratories lacked adequate facilities to conduct appropriate in-house training courses.

E. Inadequate Proficiency in Analytical Techniques

Inadequate proficiency in the analytical techniques of crime laboratory personnel was clearly demonstrated by the Forensic Sciences Foundation's <u>Laboratory Proficiency Testing Research Program</u> (LEAA Grant Nos. 74NI-99-0048 and 76NI-99-0091). The project's advisory committee attributed a primary cause for this lack of proficiency to shortcomings on the part of examiners and recommended that steps be taken immediately to correct the conditions responsible for these poor performance levels. Education and training programs such as these microscopy workshops are an important means of upgrading the analytical skills of forensic examiners.

The "Proficiency Testing" results highlighted a number of types of evidence where laboratories were experiencing difficulty. Those requiring the proper application of light microscopy --- such as glass, hair, fibers, paint, soils, drugs, wood, paper, and firearms --- were among the most problematic.

CHAPTER II. METHODOLOGY

A. Organization of the Workshop Steering Committee

Selection of the project's advisory committee --- the Workshop Steering Committee (WSC) --- was the initial task of the project. The WSC was responsible for overall project guidance and internal evaluation. Dr. Walter McCrone, the project's principal instructor, and six other persons were invited to serve on the advisory committee. The members of the WSC and their professional affiliations are as follows:

Harold A. Deadman
Laboratory
Federal Bureau of Investigation
Washington, D.C.

Peter R. De Forest
John Jay College of
Criminal Justice
New York, New York

Bart Epstein
Minnesota Bureau of
Criminal Apprehension
St. Paul, Minnesota

Dale H. Heideman
Florida Department of Criminal
Law Enforcement
Tallahassee, Florida

George Ishii
Western Washington Regional
Crime Laboratory
Seattle, Washington

Walter C. McCrone
McCrone Research Institute
Chicago, Illinois

John I. Thorton
School of Public Health
University of California
Berkeley, California

The selection committee, comprising project staff, national and regional forensic sciences association officials, and the LEAA project monitor, appointed WSC members having diverse forensic science occupations and professional experience. As noted above, committee membership included two academicians who were also involved in private forensic casework, a crime laboratory director, a director of training for a statewide laboratory system, and two forensic examiners --- one representing a state forensic laboratory system, the other, the Federal Bureau of Investigation.

All WSC members were engaged in forensic occupations that required extensive use and comprehensive understanding of criminalistics. Most members of the committee had expertise in those specialized forensic science areas --- botanical materials, hair, fibers, soil, glass, safe insulation, drugs, dust, pollens, explosives, gunshot residue, paint, and forensic chemistry --- which relied substantially on the proper use of the microscope.

WSC members also had extensive experience in training forensic scientists, using student evaluations, test development, and classroom lecturing procedures. They therefore possessed the requisite skills and experience to suggest improvements in methods; they could also appreciate the problems that can accompany a major training program. A majority of the steering committee members were actively engaged in training forensic scientists as a part of their daily occupation. Committee members represented and maintained liaison with regional forensic sciences associations, including:

California Association of Criminalists
Mid-Atlantic Association of Forensic Scientists
Midwestern Association of Forensic Scientists
Northwestern Association of Forensic Scientists
Northeastern Association of Forensic Scientists
Southern Association of Forensic Scientists

As an extension of their advisory function, WSC members were designated as site coordinators for workshops held in their regions. Drawing on their familiarity with the regions, members were able to obtain the most favorable training facilities in which to hold the workshops, and could recommend and coordinate local travel and lodging arrangements for students and instructers. If WSC members were unable to attend the course or coordinate the local workshop arrangements, they recommended alternate site coordinators in their regions.

B. Development of Workshop Curriculum

Dr. McCrone and the McRI instructional staff developed the curriculum for the Forensic Microscopy Workshops. An outline of the curriculum follows:

FORENSIC MICROSCOPY WORKSHOP CURRICULUM

<u>Day 1</u>

Lecture	Introduction, brief history of forensic microscopy, physical optics, types of microscopes useful in criminalistics, polarizing microscope, illumination, micrometry.
Laboratory	Familiarization with the polarizing microscope and illumination, micrometry, study of human hair diameter and scale count.
Lecture	Crystal morphology: systems, axes, forms, habit, symmetry; microchemical reactions.
Laboratory	Recrystallization from vapor and solution on a microscope slide; microchemical tests.

<u>Day 2</u>

Lecture	Refractive index and variation with atomic number, wavelength and temperature; Polarized light; Crystal Optics I.
Laboratory	Measurement of refractive indices for isotropic and anisotropic substances.
Lecture	Dispersion staining fibers, safe insulation, drugs, explosives, soil materials.
Laboratory	Applications of dispersion staining.

<u>Day 3</u>

Lecture	Crystal Optics II, retardation, birefringence, compensators, interference figures.
Laboratory	Study of fibers, birefringence, and sign of elongation: conoscopic observations.
Lecture	Characterization and identification of small particles (biological, mineral, industrial, and combustion products).
Laboratory	Study of known particles.

<u>Day 4</u>

Lecture	Sampling methods, preparation methods, supplementary methods (squoosh test, staining, magnet, density, crystal-rolling), particle classification.

Laboratory	Identification of unknowns.
Lecture	Visual thermal analysis, characterization of drugs and explosives, polymorphism and composition diagrams.
Laboratory	Study of explosives and drugs.

Day 5

Lecture	Special methods (phase, fluorescence, SEM, TEM, XRD, EMA, IMA) particle fractionation, isolation, manipulation; microminiaturization of tests and measurements; photomicrography.
	General discussion and questions: sources and resources, microscopes and accessories, standard methods, proficiency tests, etc.

The WSC modified this general curriculum to meet the needs of each regional workshop and to correspond with the equipment capabilities of the crime laboratories in these regions. The WSC reviewed the results of the LEAA/NILECJ Crime Laboratory Proficiency Testing Research Program to determine the focus of the individual workshops. Those types of physical evidence that had caused a significant degree of difficulty during the proficiency testing were emphasized at the regional workshops.

C. Establishment of Student Eligibility Criteria

The WSC, in consultation with project staff and regional association officials, discussed at length the criteria and objective measurements for student eligibility for the workshops. They decided to require minimum laboratory and personal qualifications as prerequisites for taking the course.

1. Laboratory requirements. Every effort was made to ensure that the skills learned at the workshops would be incorporated in the working routine of the home laboratories. Laboratory directors were asked to certify on the application that those personnel selected for the workshops would be allowed

sufficient time at work to prepare workshop readings and assessment examinations. Then, after the workshop, they were to be allowed sufficient time to (1) complete follow-up bench tests, (2) incorporate the new techniques into laboratory procedures, and (3) formally communicate their newly learned skills to laboratory co-workers, especially those who were recommended but not selected to attend the workshops. The laboratory director also had to declare that the equipment necessary for incorporating the training methodologies into their laboratory operations were currently available or on order in the home laboratory.

2. Student selection criteria. To be selected for the workshops, applicants had to have either a baccalaureate degree in chemistry, physics, biology, biochemistry, forensic science, or medical technology, or equivalent preparation. Previous experience in microscopy was recommended but not required. Students had to agree to prepare assignments in advance of the training workshop, to participate in several classroom examinations and in follow-up, blind sample testing after completing the training, and to share their newly learned techniques with scientists at their home laboratories.

D. Student Application Procedures

A procedure for soliciting student applications was devised by the WSC and administered by the Forensic Sciences Foundation (FSF) project staff. Information packages were distributed to all crime laboratory directors. Those administrators interested in enrolling students were instructed to submit an application to the FSF for each student. A single application was enclosed with the information package; this form was to be duplicated if needed for additional students. Also included with the application materials was a cover letter enclosing the course structure, application procedures, tentative workshop schedule, list of supplies furnished by McRI, syllabus, laboratory equipment and supply requirements, pre-workshop assessment examination, a memorandum from Dr. McCrone, and the names and affiliations of the workshop steering committee members. The application is attached in Appendix A.

The possibility existed that some laboratories might enroll several persons in a given workshop early in the application time period which could rapidly fill the course to capacity. This set of circumstances was anticipated and discussed by the WSC at their first project advisory meeting. If applications were accepted on a first-come first-served basis, examiners from laboratories which required more red tape to submit applications might be denied admission to a workshop due to lack of space. Thus an inequitable situation could arise whereby some laboratory directors would be able to enroll several of their examiners in a given workshop while others would be unable to train anyone from their laboratores.

In an effort to offer this training to examiners from as many laboratories as possible, and to ensure that each laboratory was afforded an equal opportunity to enroll qualified students, the WSC designed a ranking procedure whereby directors could assign priorities to each student they desired to enroll. Students assigned the highest rank would be admitted to the course before all students ranked second, and so forth. In this way, one person from each laboratory was enrolled before additional students from that same laboratory.

A pre-workshop assessment examination was included with the application package. This examination, which each applicant completed, surveyed the student's motivation to attend the course and assessed the student's knowledge

of specific topics that the instructors considered important for successfully completing the workshop. These topics included the student's familiarity with chemical nomenclature and the ability to diagram projections of crystals. A number of items related to the parameters of the microscope and microscopy. The examination served as a guide for the instructors who could then teach the course based on the knowledge level of the class. The pre-workshop assessment (Appendix B) was used by the instructors for information only and did not influence the decision to accept or to reject a student.

E. Selection of Instructors

Dr. McCrone and Mr. Palenik served as primary instructors for the 20 microscopy workshops. The workshop locations and instructors are listed below:

Workshop Location	Instructor
Orlando, Florida	McCrone
Atlanta, Georgia	McCrone
Raleigh, North Carolina	Palenik
Washington, D.C.	McCrone
Storrs, Connecticut	McCrone
Chicago, Illinois	Palenik
London, Ohio	McCrone
Denver, Colorado	McCrone
Seattle, Washington	McCrone
Chicago, Illinois (Advanced Botanicals)	Palenik
Chicago, Illinois (Advanced Soils)	McCrone
Modesto, California	Palenik
Los Angeles, California	McCrone

Workshop Location	Instructor
Phoenix, Arizona	McCrone
Austin, Texas	Palenik
Shreveport, Louisiana	McCrone
Chicago, Illinois (Advanced Botanicals)	Palenik
Baltimore, Maryland	McCrone
Chicago, Illinois (Advanced Soils)	McCrone

Dr. McCrone taught 11 basic microscopy and 3 advanced soils workshops. Mr. Palenik taught 4 basic microscopy and 2 advanced botanicals workshops. Two guest instructors--experts in the subjects of wood and pollen--were utilized by Mr. Palenik at the first advanced botanicals workshop. Enthusiastic, positive feedback from students and the WSC prompted Mr. Palenik to use a guest instructor again at the second botanicals workshop.

F. Selection of Workshop Sites and Dates

The instructional staff held the workshops in police training academies, police headquarters, university classrooms, and motel conference rooms. Site selection was based on the location of applicants in each region and on the availability of local laboratory facilities. Workshop space was rented only after other efforts to obtain space had been exhausted.

G. Regional Association's Option to Sponsor Its Own Workshop

The option to sponsor an individual workshop program was not exercised by any of the regional forensic sciences associations. One regional association wanted to hold a less intensive, introductory microscopy workshop, utilizing project equipment and supplies, prior to the LEAA sponsored workshop. Student enrollment was insufficient to justify two successive workshops, however, so the two staffs of instructors combined the regional course with the LEAA sponsored workshop.

H. Course Structure

Decisions relating to subject emphasis, equipment and facility requirements, instructional handouts, lesson plans, and instructional training needs were primarily the responsibility of McRI, although the WSC and the project staff had substantial input into the final decisions. The forum for many of these discussions was the WSC advisory meetings that were held periodically during the project. At these meetings, McRI instructional staff presented preliminary recommendations relating to the course structure, which then were reviewed--and modified if necessary--by the WSC.

The core curriculum remained constant throughout the series of basic workshops. Digressions from or modifications to the basic course outline were made by the instructional staff, based on input from the WSC, site coordinators, and students.

The WSC decided to offer advanced, special-topics workshops to those students successfully completing the basic microscopy workshop or its equivalent. Unlike the basic courses, which were held regionally, the advanced courses were conducted at the McCrone Research Institute in Chicago, Illinois. Specific topics for the advanced courses were selected by the WSC after reviewing the <u>Crime Laboratory Proficiency Research Program</u> results which showed that laboratories were experiencing particular problems in analyzing soils and wood - two areas of analysis for which microscopy is particularly applicable.

All necessary equipment and supplies for the basic and advanced workshops were provided by McRI. A list of these course materials is presented in Table 2. Figure 3 depicts these materials ready to be loaded into the workshop van. Specifications describing "ideal" course facilities and space requirements were developed by McRI staff; these requirements could not always

TABLE 2

COURSE MATERIALS

(Provided By McCrone Research Institute)

A. Each student and the instructor will have:

1 Olympus POS microscope
1 Olympus LSD illuminator
1 Course manual
1 Set of 100 prepared slides
1 Dispersion staining objective
1 Stage micrometer
1 Set of solvents and Aroclor 1260
1 Notebook
1 Set of manipulative tools
1 Box of slides and coverslips

B. Each pair of students will have:

2 Reagent and sample blocks
1 Set saturated aqueous solutions
1 Alcohol lamp

C. There will also be:

1 Closed circuit TV system (Figures 4 and 5).
1 Public address system and lectern
1 Carousel slide projector
1 Set of refractive index liquids 1.3-1.8
1 Set of high dispersion index liquids 1.5-1.65
1 Oil immersion objective and bottle of immersion oil
2 Quartz wedges
1 Olympus 35-mm photomicrographic camera
1 S & M exposure meter
1 Set of tools
1 Tiyoda microscope
1 McArthur microscope
1 Mettler hotstage
1 100-fiber reference set
1 20-slide animal sperm set
8 Cargille sets of prepared slides
1 Library of reference books
1 Hot plate
2 Aroclor 5442

Each student may bring his (or his laboratory's) polarizing microscope for evaluation, cleaning, adjustment, and recommended upgrading or replacement. McCrone Research Institute will furnish up to 25 complete polarizing microscopes as well as all visual aids and course materials.

FIGURE 3

WORKSHOP MATERIALS

FIGURE 4

Closed-Circuit TV System

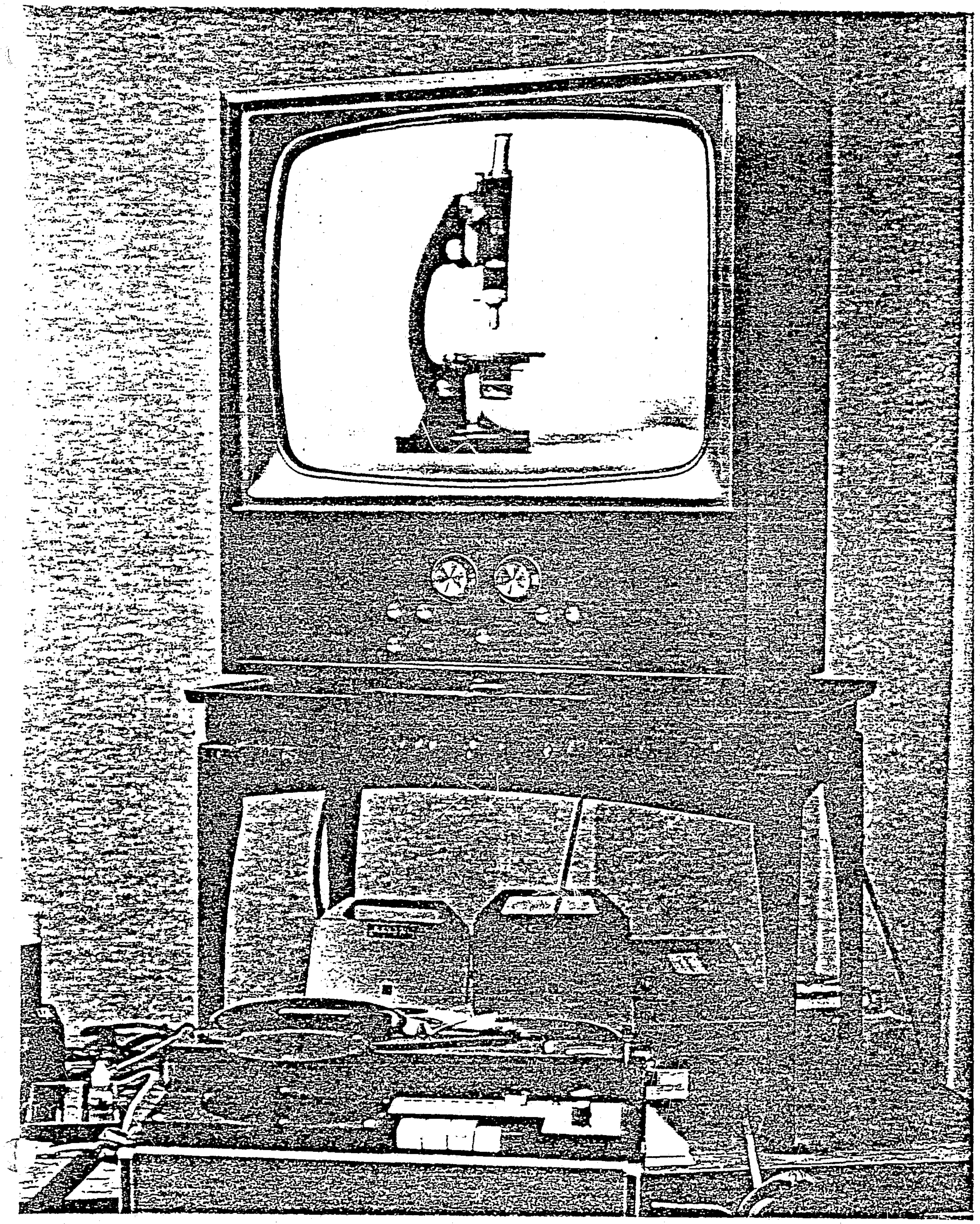
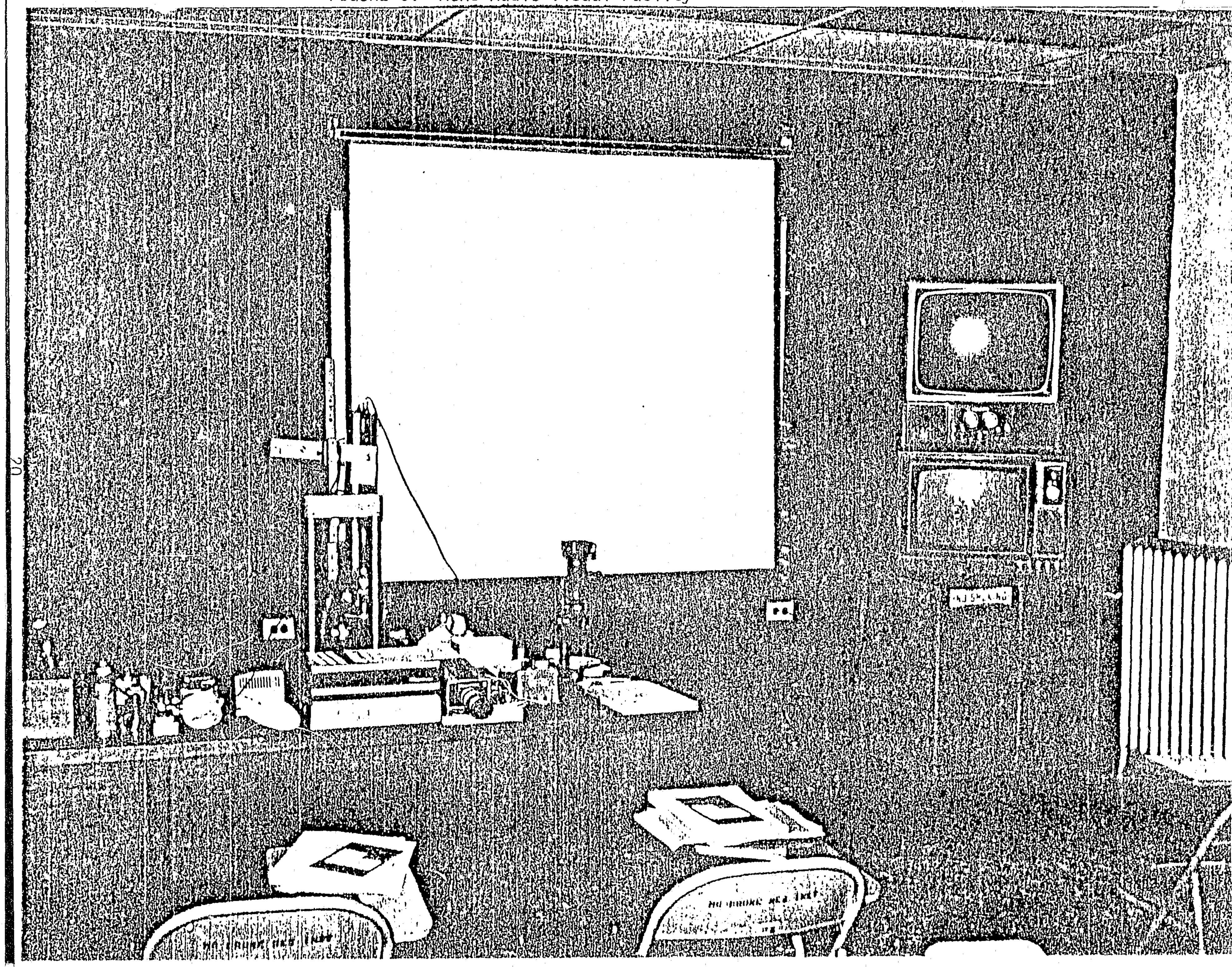


FIGURE 5: McRI Audio-Visual Facilty



be satisfied. Preferable classroom facilities included a separate lecture room arranged theatre style with dimensions greater than 6 by 10 meters. Figure 6 shows a typical classroom setting. One square meter of table-top space was recommended for each student. To facilitate comfortable viewing with the microscope, and 8-to-10-inch height differential between the student's seat and the table-top was indicated and was accomplished using various improvised methods. A classroom or separate lecture room was needed that could be darkened to project slides.

Charts, handouts, physical evidence test samples, projection equipment, demonstration models, and an assortment of textbooks were supplied at all workshops by McRI. These materials, and the microscopes and supplies, were transported between sited by the McRI staff in the Institute's van, depicted in Figure 7. (Examples of the handouts are given in Appendix C).

I. Administrative Planning

Administrative planning responsibilities were divided among the FSF and McRI staffs and local site coordinators.

1. FSF administrative duties. The FSF staff members were responsible for coordinating workshop publicity and distributing workshop applications. Using its comprehensive mailing list of crime laboratory directors, the FSF staff informed laboratory directors, nationwide, of the training workshops and set in motion the workshop application procedures. Crime laboratory directors were sent complete information packets containing course descriptions, requirements, and applications, and instructions detailing the application procedures.

Workshop publicity materials were distributed to editors of regional forensic science association publications, the LEAA newsletter, and publications relating generally to criminal justice and forensic science. LEAA's Selective Notification of Information (SNI) distribution system was also utilized to distribute workshop announcements, as shown below:

FIGURE 6: CLASSROOM SETUP

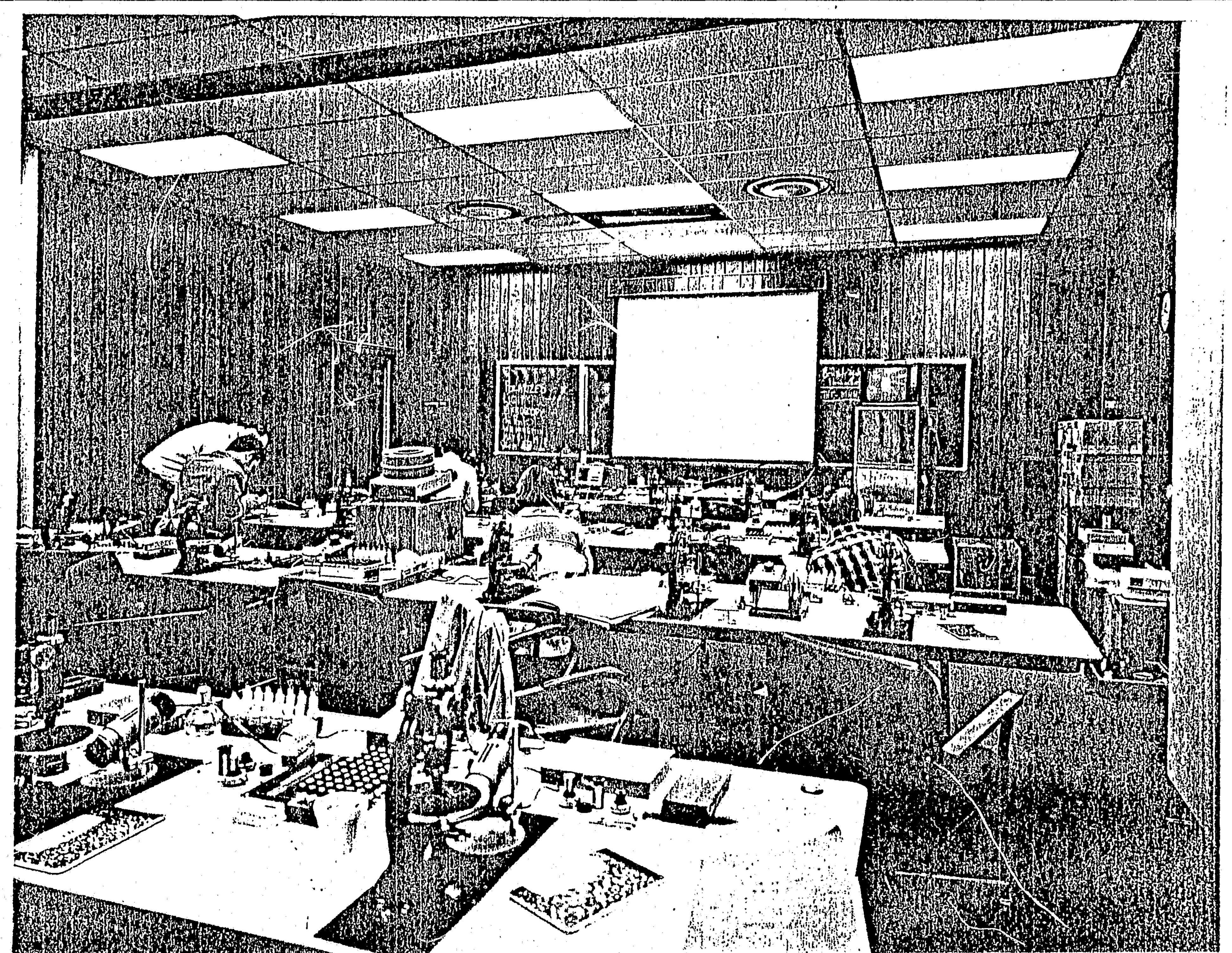
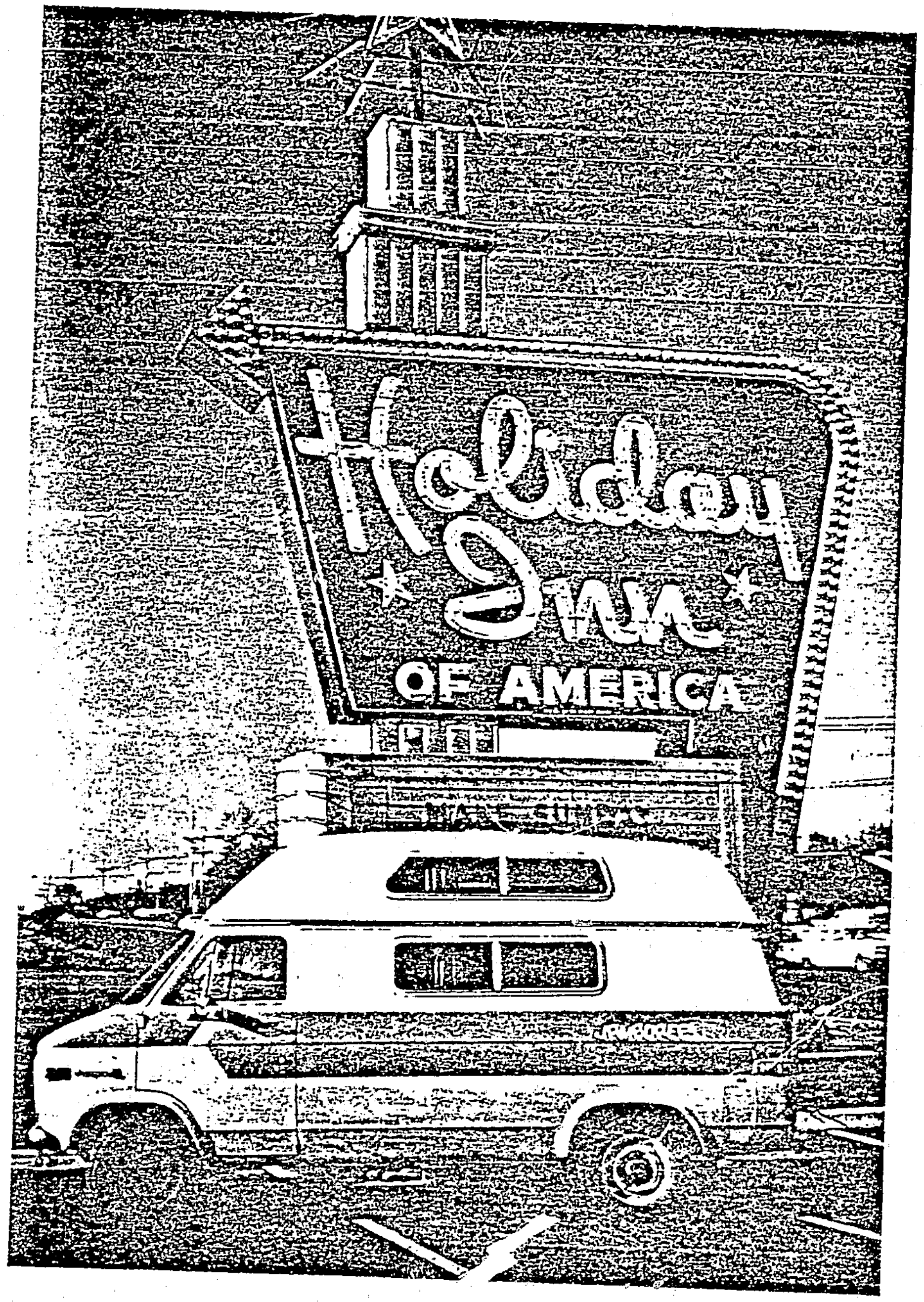


FIGURE 7

WORKSHOP VAN



U.S. DEPARTMENT OF JUSTICE
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE, WASHINGTON, DC 20531

CRIMINAL JUSTICE ACTIVITY ANNOUNCEMENT

NCJ — 99117

SELECTIVE NOTIFICATION OF INFORMATION

FORENSIC MICROSCOPY WORKSHOPS

The Forensic Sciences Foundation will hold a series of week-long regional forensic microscopy workshops covering
basic and advanced special topics instruction in the application of microscopy to the examination of various types
of physical evidence. Onsite instruction will be provided by the McCrone Research Institute of Chicago, Illinois.
BASIC WORKSHOPS: The tentative schedule is Northern and Southern California, January, 1979; Southwest Region and
Texas, February 1979; Louisiana and Southeast Region, March, 1979; Mid-Atlantic and Northeast Regions, May, 1979.
ADVANCED WORKSHOPS: Two advanced workshops will be held twice in Chicago, Illinois, in December, 1978 and April,
1979 (tentative dates). Workshop #1 will cover wood, pollens, paper, pulp, and plant fibers; Workshop #2 will
include soils and mineralogy. Applicants must have had a previous course in basic microscopy. A list of minimum
requirements for applicants and their laboratories is available on request. The $65 fee covers the cost of the
workshops; travel and living expenses are additional. For additional information, contact: Ira T. Silvergleit,
Project Director, Forensic Sciences Foundation, 11400 Rockville Pike, Suite 515, Rockville, MD 20852. Telephone:
(301) 770-2723. This grant is funded by the National Institute of Law Enforcement and Criminal Justice and the
Law Enforcement Assistance Administration

NCJRS — National Criminal Justice Reference Service — an international clearinghouse for criminal justice information ☆ U.S. G.P.O.: 1978--260-994/2920

Student applications were retured to the FSF and were screened initially to determine whether the applicant or laboratory met minimum educational, fee payment, director certification, and equipment requirements. The pre-workshop assessment examinations were also checked. Applicants then were notified either by post card or form letter whether their applications were complete or whether further information was required. Copies of the notification documents follow.

Dear Forensic Scientist:
Your application is complete for the Forensic Microscopy Workshop scheduled for:

Site: ____________________

Address: ____________________

City: ____________________ State: ____________

Dates: ____________________

You will be notified by the McCrone Research Institute approximately four weeks prior to the workshop concerning your acceptance.

Please contact ____________________ who is the site coordinator for this workshop if you will require lodging. Tel: ____________

If you have any questions, please contact Ira T. Silvergleit, Project Director at FSF: Tel.: (301) 770-2723.

FORENSIC MICROSCOPY WORKSHOP STEERING COMMITTEE

HAROLD A. DEADMAN
Federal Bureau of Investigation
Washington, D.C.

PETER R. DE FOREST
John Jay College of Criminal Justice
New York, New York

BARTON P. EPSTEIN
Minnesota Bureau of Criminal Apprehension
St. Paul, Minnesota

DALE H. HEIDEMAN
Florida Department of Criminal Law Enforcement
Tallahassee, Florida

GEORGE G. ISHII
Western Washington Regional Crime Laboratory
Seattle, Washington

WALTER C. McCRONE
McCrone Research Institute
Chicago, Illinois

JOHN I. THORNTON
University of California
Berkeley, California

FORENSIC SCIENCES FOUNDATION STAFF

JOSEPH L. PETERSON
Project Supervisor

IRA T. SILVERGLEIT
Project Director

McCRONE RESEARCH INSTITUTE INSTRUCTIONAL STAFF

WALTER C. McCRONE
SKIP PALENIK

THE FORENSIC SCIENCES FOUNDATION, INC.

11400 Rockville Pike • Rockville, Maryland 20852 • (301) 770-2723

DATE:

TO: Applicant, Forensic Microscopy Workshop

FROM: Ira T. Silvergleit, Project Director

SUBJECT: Status of Application

Thank you for your application for our LEAA sponsored forensic microscopy workshops.

A delay has occurred in the processing of your application for the following reason(s).

_____ Part I: _____ missing _____ incomplete

____

_____ Part II _____ missing _____ incomplete

____

_____ Pre-workshop Assessment Examination
_____ missing _____ incomplete

____

_____ Please specify below which basic workshop you desire to apply for:
Location_______________________________
Date___________________________________

_____ Which advanced Chicago workshop you wish to apply for:

_____ Advanced I - Wood, Plants - December 1978
_____ Advanced II - Soils, Mineralogy - December 1978
_____ Advanced I - Wood, Plants - April 1979
_____ Advanced II - Soils, Mineralogy - April 1979

_____ Other:___________________________________

____

Grant administered by the Forensic Sciences Foundation, Inc.
For the National Institute of Law Enforcement and Criminal Justice
Law Enforcement Assistance Administration
United States Department of Justice

_____ Enclosure(s):
_____ Part I
_____ Part II
_____ Pre-workshop Assessment Examination
_____ Workshop Schedule
_____ Equipment Requirements
_____ Other_______________________________

Please return the necessary information as soon as possible to expedite the processing of your application.

Completed applications were filed by workshop number; copies were forwarded to McRI for further processing. The FSF was also responsible for forwarding student evaluation forms and information concerning forthcoming advanced courses to the workshop sites.

2. McRI administrative duties. McRI made the final determination of student eligibility, based on the evaluation of the laboratory's equipment and on the education and experience of the applicant. The minimum equipment requirements are presented in Appendix D. Students who were accepted were notified by McRI and were sent a course manual, travel instructions, and reading assignments.

McRI staff selected the workshop site and the site coordinators; they also drove the van containing the microscopes and equipment between workshop sites, and set up and dismantled the classroom equipment at each workshop--often assisted by the site coordinator and the FSF project director (Figure 8).

3. Site coordinator duties. Local site coordinators provided liaison among the workshop instructors, local site officials, and students. They obtained local accomodations, coordinated travel arrangements, and aided McRI staff in setting up and dismantling the classroom. Several WSC members were site coordinators for workshops held in their regions.

J. Evaluation Design

A workshop evaluation component was built into the project, comprising pre- and post-workshop evaluations of students' knowledge, daily quizzes, practical examinations, follow-up proficiency testing, and student assessments of the training program.

1. Pre-assessment workshop examination. The pre-assessment examination, described in D (Appendix B) was used by instructional staff to ascertain the level of knowledge of the students. As stated earlier, these scores were not used to determine enrollment eligibility, but were compared with scores on the final examination.

FIGURE 8: MICROSCOPE SETUPS

2. Quizzes and sample unknowns. Students were given a quiz most mornings of the week-long workshop to determine whether they were understanding the material and whether they were keeping up with their reading and homework assignments. Examples of these quizzes are attached in Appendix E. Quiz scores were made available to students as soon as they were graded, often before the lunch break.

Students were given the opportunity to examine samples of unknown materials each day of the workshop. Instructors provided rapid feedback to students concerning their analysis and spent considerable time correcting problems individual students had with samples before progressing to subsequent stages of the instruction. On the final morning of the class, a sample unknown was distributed for students to analyze.

3. Microscope illumination checks. During the workshop, instructors stressed the importance of proper illumination of microscopic specimens. Students were graded periodically on their ability to produce high-quality Köhler illumination using the light sources supplied by McRI. The instructor would sometimes misalign the lighting at each microscope before students arrived for class to test the students' ability to recognize less than optimal illumination and to challenge the students' skills in producing proper illumination. McRI's workshop handout describing how to obtain Köhler illumination is attached as Appendix F.

4. Final written examination. A final written examination (Appendix G) was administered to students on the final morning of the workshop.

5. Follow-up proficiency tests. Several months after completing the workshops samples of unknown materials were sent to students to identify. These examinations were to be completed in the students' home laboratories using the techniques learned at the microscopy workshops.

For students completing one of the 15 basic workshops, the test consisted of three unknown samples: an organic explosive, an inorganic explosive, and a mixture of at least three fibers. Accompanying the test was a digest of applicable microscopical background data and methods. To receive a passing grade and a workshop certificate, students were required to correctly identify both explosives and two fibers after having successfully completed the in-class portion of the workshops. In cases of misidentification, students were informed of the error, asked to rework the tests, and forward their results to McRI.

All advanced-workshop students were required to perform at least three proficiency tests during the course. Only after successful execution of all previous work and tests was a new proficiency test assigned to the student. The workshop proficiency test is attached as Appendix H.

6. Student workshop evaluations. A Forensic Microscopy Workshop Evaluation Form requesting information on the quality of the workshops was given to students on the final morning of each workshop. Using a 7-point scale, participants were asked to rate, anonymously, the overall value of the workshop, how well the course met their expectations, whether the course covered the information and skills it should have covered and whether they had improved as forensic microscopists.

They also evaluated the quality of instruction, whether they would recommend this course to other scientists from their laboratories, the relevance of the course to their work, the fairness of grading, and the best liked and least liked sections of the course. Students were asked to suggest course improvements and to recommend other topics that should be offered in similar workshops in the future. This evaluation form is attached as Appendix I.

U.S. DEPARTMENT OF JUSTICE
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE, WASHINGTON, DC 20531

CRIMINAL JUSTICE ACTIVITY ANNOUNCEMENT

NCJ — 99117

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SELECTIVE NOTIFICATION OF INFORMATION

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Dear Forensic Scientist:
Your application is complete for the Forensic Microscopy Workshop scheduled for:

Site: ______________________

Address: ______________________

City: ______________ State: __________

Dates: ______________________

You will be notified by the McCrone Research Institute approximately four weeks prior to the workshop concerning your acceptance.

Please contact ______________________ who is the site coordinator for this workshop if you will require lodging. Tel: ______________

If you have any questions, please contact Ira T. Silvergleit, Project Director at FSF: Tel: (301) 770-2723.

A. Participation

1. Student enrollment. The LEAA grant enabled the Forensic Sciences Foundation and the McCrone Research Institute to conduct 20 forensic microscopy workshops that resulted in the training of 357 scientists. The distribution of students by workshop is as follows:

Number of Students Per Workshop

Course No.	Location	No. of Students	Cumulative No. of Students
1	Orlando, FL	20	20
2	Atlanta, GA	21	41
3	Raleigh, NC	18	59
4	Rockville, MD	15	74
5	Storrs, CT	23	97
6	Chicago, IL	19	116
7	London, OH	16	132
8	Denver, CO	16	148
9	Seattle, WA	17	165
10	Chicago - Botanicals*	11	176
11	Chicago - Soils*	11	187
12	Modesto, CA	24	211
13	Los Angeles, CA	24	235
14	Phoenix, AZ	18	253
15	Austin, TX	18	271
16	Shreveport, LA	17	288
17	Chicago - Botanicals*	16	304
18	Chicago - Soils*	20	324
19	Baltimore, MD	22	346
20	Chicago - Soils	11	357

*Denotes Advanced Workshop

This project exceeded by 57 (19%) its stated goal of training 300 scientists (Figure 9). The size of the workshops ranged from a maximum of 24 to a minimum of 11. The mean number of students per class was 17.

College and university instructors were encouraged to apply for special scholarships to attend the microscopy workshops. This served two purposes: academic instructors in the forensic sciences, especially those who had not studied microscopy previously, were afforded an opportunity to learn necessary skills, and professors had the chance to exchange information informally with those scientists working in crime laboratores on a daily basis.

2. Laboratory participation. One hundred seventy-seven crime laboratories sent at least one examiner to one of the training workshops. An average of 9 laboratories per workshop were represented during the 20 classes. The distribution of laboratories by state follows:

LABORATORY PARTICIPATION

BY STATE

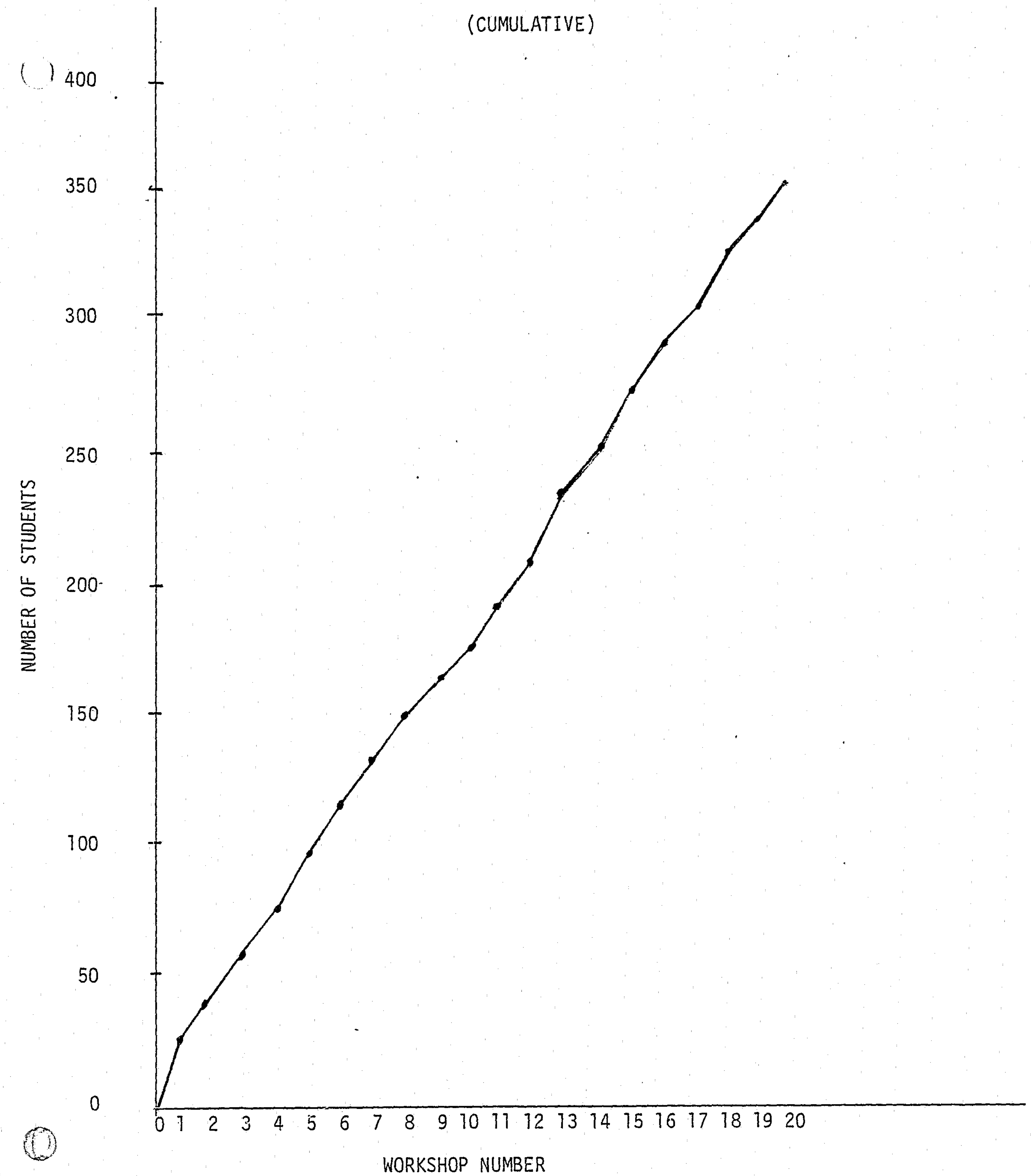
Alabama - 9
Arkansas -1
Arizona - 5
California - 37
Colorado - 4
Connecticut - 3
District of Columbia - 1*
Florida - 10
Georgia - 8
Guam - 1
Idaho - 2
Illinois - 8
Indiana - 2
Kentucky - 1
Louisiana - 6
Maine - 2
Maryland - 5
Minnesota - 1
Mississippi - 1
Missouri - 4
Montana -1
Nevada - 1
New Jersey - 3
New Mexico - 1
New York - 10
North Carolina - 3
Ohio - 8
Oklahoma - 2
Oregon - 2
Pennsylvania - 7
South Carolina - 1
South Dakota - 1
Tennessee - 2
Texas - 12
Virginia - 5
Washington - 2
West Virginia - 1
Wisconsin - 1
Wyoming - 2
Taiwan - 1

* Federal Bureau of Investigation

FIGURE 9

STUDENT ATTENDANCE

(CUMULATIVE)



B. Follow-Up Proficiency Tests

Of the 288 students who participated in the basic workshops, 53.5% (154) reported their results to McRI. 2.5% (7) indicated that they did not have access to a suitable microscope with which to complete the proficiency tests. 44% (127) failed to respond either to the initial mailing of the tests or to a follow-up letter. This communication did encourage 12 additional participants to complete the testing program.

Only one student failed all three parts of the proficiency test. Most students who did not pass incorrectly identified only one of the three sample unknowns. 98 students (64% of those responding) completed their tests satisfactorily and 55 students (35%) were in various stages of retesting. (See Table 10, Page 36). To date no student has failed the retest. Samples of some of the retesting letters are attached as Appendix K.

All students who completed the advanced courses passed the proficiency tests administered during the workshops and received certificates. In some cases, students were asked to rework proficiency samples as part of the course until the instructors were satisfied with their performance.

Considering both the basic and advanced workshops, 75% (167) of the 223 participating students have successfully completed their proficiency tests.

Some students indicated their proficiency results submitted to McRI were based on incomplete testing, due to a lack of equipment (6 students) and/or materials (11 students), such as refractive index liquids, chemicals or standards. The special sets of standard reference slides manufactured as part of this project by McRI and mailed to each participating laboratory is expected to aid students who have yet to complete their retests.

Workshop	Number of Students	Number of Test Results Returned	Number Can't Do No Equipment	Number Passed Test	No. Being Retested	Inorganic Explosives Right	Inorganic Explosives Wrong	Organic Explosives Right	Organic Explosives Wrong	Fibers Identified 0	1	2	3
1	20	7	1	6	0	6	1	6	1	0	1	1	5
2	21	14	-	10	4	10	4	14	0	0	0	7	7
3	18	3	3	2	1	2	1	3	0	0	1	1	1
4	15	3	-	2	1	3	0	2	1	0	0	1	2
5	23	7	2	2	5	2	5	7	0	0	2	3	2
6	19	15	-	6	9	9	6	13	2	1	4	2	8
7	16	14	-	11	3	13	1	12	2	0	0	5	9
8	16	7	-	2	5	2	5	6	1	0	1	4	2
9	17	9	-	7	2	8	1	8	1	0	1	2	6
12	24	15	-	11	4	13	2	15	0	0	3	3	9
13	24	12	-	7	5	9	3	11	1	0	3	7	2
14	18	11	-	9	2	11	0	11	0	0	2	3	6
15	18	12	1	7	5	8	4	12	0	0	2	6	4
16	17	9	-	5	4	8	1	8	1	0	3	5	1
19	22	16	-	11	5	11	5	14	2	0	1	8	7
TOTALS:	288	154 (53.5%)	7 (2.5%)	98 (64%)	55 (35%)	115	39 (25%)	142	12 (8%)	1	24 (16%)	58 (38%)	71 (46%)

TABLE 10 PROFICIENCY TEST RESULTS
(BASIC WORKSHOPS)

McCRONE RESEARCH INSTITUTE
2508 SOUTH MICHIGAN AVENUE
CHICAGO, ILLINOIS 60616 USA
TELEPHONE 312/842-7105

A NOT-FOR-PROFIT CORPORATION
TEACHING:
MICROSCOPY
CRYSTALLOGRAPHY
ULTRAMICROANALYSIS

17 September 1979

Dear Student:

You were sent a proficiency exam on explosives and fibers a few months ago and as yet we have no response from you. If you sent your results in please send us a duplicate. If you haven't returned your results please remember the rules say we cannot send you a certificate. If you need more samples or have any other problems with the unknowns please let me know.

Yours sincerely,

Walter C. McCrone

JB:cdb

The inorganic explosives presented greater difficulty than the organic explosives (25% versus 8% incorrect answers). The numbers of students who correctly identified the types of fibers varied: 16% of the students correctly identified one fiber; 38% identified two fibers and 46% identified all three. Some students identified up to six fibers, of which three were present as contaminants. Other students incorrectly assumed that their unknown sample would contain one type of fiber only.

C. Student Evaluations

Course evaluations were collected at the close of 19 of the 20 workshops. The only exception to this practice was in the first course held in Orlando, Florida. The FSF staff distributed follow-up evaluations through the mail to the Orlando workshop participants. Students who attended the Shreveport workshop also were sent evaluation forms, because their original evaluations were lost. Seven students from the Orlando workshop and 9 from the Shreveport workshop returned their evaluations by mail. The number of evaluations turned in by students per workshop ranged from 3 to 23. Results from workshops with a low return rate should be interpreted with caution. The number of evaluations returned per workshop is shown below:

Orlando	7	Soils I	3
Atlanta	15	Modesto	23
Raleight	6	Los Angeles	23
Rockville	14	Phoenix	17
Storrs	18	Austin	17
Chicago	17	Shreveport	9
London	15	Botanicals II	16
Denver	14	Soils II	20
Seattle	12	Baltimore	20
Botanicals I	11	Soils III	10

Thus, a total of 287 student evaluations were analyzed. The mean number of evaluations returned per workshop was 14.4.

A standard 7-point response scale ranging from low or poor (1 through 3), to neutral (4), to good or positive (5 through 7) ratings was used on the student-evaluation instrument. Thus, the highest possible rating was 7, and any rating above neutral (4) indicated a positive response.

1. Overall value of the course. The average rating by students of the overall value of the workshops was 6.0, ranging from 4.7 to 6.8 for individual workshops. The average rating for the advanced, special-topic (soils and botanicals) workshops was 6.1 out of a possible 7.

2. Student expectations. The degree of correspondence between the students' expectations of the workshops before their attendance and their actual experience was rated at 5.5. Identical average ratings resulted when the basic and advanced courses were analyzed separately.

3. Course Content. Students were asked to rate how successfully the course covered the information and skills they believed it should cover. The average rating for all workshops, and for the basic and advanced courses analyzed separately was 5.6.

4. Student confidence. This item assessed the degree to which students believed the workshop they attended resulted in a positive or negative change in their skills as forensic microscopists. An overall self-perception of improvement is evident from the 5.6 average rating of improved confidence for the combined workshops. For the advanced workshops alone, the degree of improvement in students' self-perceptions as forensic microscopists was 5.8. These ratings are related to the students' perception of their own skills and level of sophistication before taking the course--the higher the initial skill level, the less room for improvement.

5. Quality of instruction. The teaching ability of the instructional staff was rated 6.4 out of a possible 7 for the 20 workshops.

6. Skill level of the instructional staff. The participants' average rating of the instructors' skills as microscopists was 6.9. In 13 out of 20 classes, all students in the workshop awarded a 7, the highest rating to the instructor.

7. Instructors knowledge of forensic microscopy. The overall rating by participants of the instructors' knowledge of forensic microscopy was 6.8. Ratings in the basic workshops were slightly higher at 6.9; the lowest rating in any of the 20 courses was 6.2. In 6 of the workshops, all the students rated the instructors' knowledge of forensic microscopy at 7.

8. Student recommendations. Of the workshops' participants, 98.2% indicated that they would recommend these courses to others from their home laboratories. In only 2 of the 20 workshops did a respondent indicate that he or she would not be willing to recommend the workshop to a colleague.

9. Usefulness of workshops. On the average, students felt that they would utilize almost 60% of the skills and techniques taught during the workshops when they returned to their home laboratories. Independent analyses of the basic and advanced workshops showed that almost 55% of the skills learned in the basic workshops and almost 73% in the advanced workshop would be used by the students returning to their home laboratories.

10. Microscopy skill enhancement. Participants perceived that their microscopy skills had improved by at least an average of 56.2% as a result of the training workshops.* Again, it must be noted that these ratings are based on the students' perception of their own skill levels at the start and at the end of the course.

*Those responses in excess of 100% were disregarded so that the average would not be unduly influenced by a few extreme responses. Although it is possible for student to improve five-fold (i.e., a response of 500%), the authors decided to ignore such responses. Thus, the percentages quoted may be perceived as unduly "conservative" in relation to the actual responses received.

11. Grading. In response to a question concerning the fairness of the grading at the workshops, 99.3% of the respondents indicated the grading was fair.

12. Student comments. Students were asked what they liked most and least about the workshops, and how the courses might be improved in the future. Responses focused upon the coursework, training facilities and accommodations, although there were comments upon most other aspects of the project. Responses indicated that many students recognized and approved of the practicality built into the workshops--including components of the lectures and laboratory exercises. The instructional staff was commended for its high level of knowledge, enthusiasm, and dedication. Students also commented favorably on the teachers' being available to participants from the early hours of the morning to late in the evening, well beyond the posted workshop hours.

Student criticism focused mainly on the amount of material covered during the one-week workshop. "Too much material in too little time" was a theme repeated in many responses. Some respondents also stated that the course was "rushed" or proceeded "too fast," while others were unhappy about the long hours of study required if one were to keep up. Some felt that the teaching staff placed too much emphasis on theoretical material.

Most suggestions for improving the workshops were derived from the negative responses listed above. The most frequent suggestion was that the workshop be lengthened; a two-week course being suggested most often. Other proposals called for a reduction in the amount of material to be covered or for the instructor to proceed at a slower pace. Another frequently voiced suggestion called for the advanced reading material to be distributed to students at least two weeks before the workshop is scheduled to begin.

General comments touched upon many other aspects of the program. They ranged from statements of appreciation from students who were grateful for having had the opportunity to study under Dr. McCrone or Mr. Palenik to the comments of one student who lamented that the course was the most intense instruction he had experienced since "SWAT" training.

13. Additional topic suggestions. Participants suggested a variety of topics for future training workshops. Those topics proposed by at least ten persons and the frequency each was mentioned are:

Topic	Frequency	Topic	Frequency
Fibers	63	Explosives	25
Hair	54	Plant Materials	22
Soils/Mineralogy	44	Glass	18
Paint	36	Microchemical tests	16
Drugs	33	Wood	13
		Serology	13

A complete tabulation of proposed topics is included as Appendix L.

D. Instructor, Site Coordinator, WSC Evaluations

The evaluations by workshop principals were valuable in obtaining candid assessments of administrative and instructional components of the workshops by those most closely involved in the course planning. Problems occurring at each workshop were noted on the evaluation form, along with the steps taken to remedy them. This information was than used to avoid similar problems at future workshops. A sample of the comments are as follows:

- Site coordinator duties should be limited to local arrangements and not include instruction at the workshops.
- Workshop hours should be extended to 8AM - 5 PM.
- Project staff should require workshop reservations to be received in writing from laboratory directors.
- Textbooks should be forwarded to participants at least 2 weeks prior to the workshops.

- Some site coordinators had furnished materials (slides, coverslips, lab alcohol, tissues, etc.) from their laboratories to the workshops when supplies ran low.
- The instructors on occasion gave individual after-hours instruction to those students who were forced to miss a day of instruction due to court appearances.
- It is important to hold workshops away from students' home laboratories to minimize distractions and interruptions and maximize concentration. Nevertheless, transportation and lodging costs do mitigate against this practice.
- Lodging accommodations should be in close proximity to the teaching facility so as to encourage students to return to the laboratory after normal workshop hours.

E. Examinations and Grades

A typical basic-level workshop included 4 quizzes, (on Tuesday, Wednesday, Thursday, and Friday mornings), 3 microscope illumination evaluations (on Monday, Wednesday, and Thursday mornings), a morphology quiz and a written final examination. Occasionally, an examination consisting of unknowns was administered on Friday mornings. Numerical averages were computed and converted into letter grades (A through F). Students were then ranked according to their performance in the workshop. Since each instructor used a different evaluation technique and grading criteria varied across workshops, no effort is made in this report to compare grades among workshops.

F. Standard Reference Microscope Slide Sets

One set of standard reference microscope slides was issued to each laboratory that sent a student to the workshop. The instructional staff selected ten categories of trace evidence and prepared 6 to 8 types of substances in each evidence category. Sets of approximately 80 slides, distributed to each of the over 180 laboratories participating in the program, necessitated the preparation of more than 15,000 slides.

G. Workshop Certificates

After successfully completing the workshops and follow-up blind sample tests and course evaluations, the student was issued a certificate of completion. Sample certificates for the basic and advanced workshops are presented in Appendix M.

H. Monograph

The project has produced a monograph entitled "A Summary of the State of the Art of Forensic Micrscopy."

CHAPTER IV. FUTURE WORKSHOPS MODEL

Efforts to upgrade the quality of work in the nation's crime laboratories must be continued. The training administered through the NILECJ-sponsored Forensic Micrscopy Workshops is a significant initial effort to bring severely needed instruction to laboratory examiners in only one aspect of the forensic sciences. Training in the proper utilization of the microscope should be but often is not a key element of the forensic scientists's training. A one-week intensive course of basic instruction offers only a superficial look at many of the specialized areas of criminalistics where the use of the microscope is essential.

The Forensic Microscopy Workshops project staff and steering committee believe that the project has developed a mechanism for the successful presentation of nationwide training programs that can serve as a model for future nationwide training efforts. Modifications of this "future workshops model" will likely be required for subsequent training programs, but the basic model can serve as a basis for planning and administrative efforts and thus avoid "rediscovering the wheel." Also, many of the problems encountered and resolved during these workshops can be avoided in future training ventures. The model is also applicable with alterations to local and regional training programs.

A. Conceptualizing the Workshop

1. Choosing the workshop topic. Training programs should be designed to respond to deficiencies in training. The timing and the context in which the training is to take place and the scope of the sponsoring organization's responsibilities in most instances will determine the method through which training needs will be identified. Evidence of the need for training may result from an assessment or testing program, from the input of participants at previously

conducted training sessions or conferences, or from surveys or informal inquiries. Workshop topics may then be selected, with consideration given to the need for a general or specific course, scope of coverage, and subject emphasis. Factors that must be considered during this phase of planning include the severity of the need for training, the subject matter of the topic, the time available to conduct the course, and the appeal to potential students and their supervisors of the subject. Administrative problems, such as students securing permission from directors of laboratories who must approve attendance by the staff at such workshops, and the possibility that other organizations might be planning to offer similar training must also be considered.

2. Selection of instructional staff. Perhaps no decision is of greater importance to the success or failure of a training program than the choice of instructional staff. Besides selecting for overall competence, weight should be placed on the teaching skills and reputation of the instructor. Too often, workshops have failed because instructors, although knowledgeable in a subject area, are poor teachers and cannot communicate effectively with students.

The instructor must be willing to cover the topic at the intellectual level of the students. An instructor can overestimate or underestimate the level of sophistication and comprehension of students. In either situation, the training will not be effective, and students might become totally alienated by the end of the session.

A key decision is whether to use an academician or practitioner as the workshop's principal instructor. Although considerable searching may be required to find ther person who embodies the best characteristics of both, there are persons who possess such backgrounds and every effort should be made to attract them. An alternative might be to employ a "co-instructional or team teaching" concept using two or more instructors, or to use adjunct lecturers for specific topic areas. Some pitfalls to this apprach, however, include professional jealousy, adherence to competing methodologies, and personality conflicts between or among the instructors.

3. Utilizing an advisory board. A training advisory board distinct from the instructional staff can serve a valuable function and generally should be encouraged, depending on the scope of the program and available funding. Existing groups such as the education committee of a regional forensic science association or a panel of laboratory directors or supervisors could make up the board. The advisory panel should be selected carefully, using the following criteria:

- Knowledge of subject and training procedures.
- Professional affiliations
- Geographical diversity
- Agency distribution (state, local, and federal agencies).
- Job classification (bench versus management status).

If an advisory board is used, it should be involved in all phases of the workshop planning and administration. Panel members can offer valuable insights to the project staff, providing information that would not be routinely considered by persons not involved in the daily work of a laboratory or educational institutions. Ideally the committee should be given the opportunity to meet with administrative and instructional staff at least once before and once during the project and, if possible, once again toward the end of the program to discuss future training recommendations.

4. Determining class size and length. In most cases, a limit must be placed on student enrollment, which will usually necessitate the development

of rules to govern who will be selected to attend the workshop. The size of the class will depend on many factors, including:

- Equipment availability.
- Number of instructors.
- Capacity of training facility.

For courses with a single instructor, 15 students should be considered a "rule-of-thumb" upper limit. It is advantageous to select students for a workshop who's backgrounds are similar in education, training, and experience. This enables the instructor to tailor the course to more closely fit the needs, capabilities and interests of the students.

When overenrollment in the workshops in anticipated, it might be preferable to allow only one participant per laboratory into the course before additional persons from that laboratory are accepted. Laboratory directors who wish to enroll more than one student can be requested to rank students in order of preference.

Class length depends on a number of factors, including the subject to be covered and the cost of tuition, per diem, and travel. Most laboratories cannot afford to be without examiners for more than two weeks, so two weeks is the practical maximum length for a workshop.

B. Designing the Workshops

1. Selecting the course title. Once the workshops have been conceptualized, the next phase of the administrative process involves the "nuts and bolts" of course planning. Many decisions face the administrator, starting with the selection of a suitable workshop title. Although the title designation may seem unimportant, administrative and political decisions regarding student participation can be influenced by it. For instance, if a workshop is designated a "basic" course, administrators may have difficulty justifying participation by a worker with experience in that field regardless of how badly the training is needed.

Using such terms as "remedial" is also ill-advised because of their negative implications. On the other hand use of the term "advanced" in a workshop title may tend to discourage some parsons from taking the course. Obtaining permission to enroll in a course may be easier for a worker in a crime laboratory when the title includes terms such as "forensic," "laboratory," and other terms relating to the laboratory or agency goal rather than a more general title. "Forensic Microscopy for Laboratory Personnel" may thus attract greater participation than a workshop entitled simply "Microscopy." Course titles and syllabi should be flexible enough for the instructor to modify the workshop if necessary.

2. Choosing a site. Site selection does not present a serious problem, as long as a few basic considerations are given serious thought. Sites should be selected to best accommodate the majority of the attendees. Site selection criteria should consider air and ground transportation connections and the cost and proximity of lodging and food services. Police academy training facilites and university classroom and dormitory space should be considered. Setting up classrooms in laboratory buildings is a second possibility. Hotel or motel meeting sites might be acceptable except for laboratory courses that might require special equipment or capabilites. Infrequently, other considerations might influence the choice of a workshop site. For instance, some jurisdictions prohibit students from attending training workshops or meetings held in states that have not ratified the Equal Rights Amendment. Some locations have seasonal fluctuations in accommodation availability, with "off-season" and "tourist-season" rates. Vacation periods at colleges and universities offer opportunities to obtain meeting rooms and lodging free or at very reasonable rates.

3. Tuition. Tuition levels will depend on the planner's estimate of workshop expenses. When calculating the tuition, a moderate tuition discount

for early registration or fee payment should be considered. If the sponsoring agency computes the time and cost involved in billing students for tuition, the cost advantages of offering the discount for early fee payment with registration becomes evident. Even when government funds are available to offset workshop costs, the student or his or her agency should be charged a small fee, because this tends to increase a student's motivation to learn and discourages agencies from using workshops simply as vacations or rewards for employees.

Either partial or full scholarships for deserving students and educators should be encouraged, especially for those who are enrolled in or teach in graduate programs. Training received by students while still in school probably produces better results than training received later in their careers. Good study habits are still practiced and improper work habits have not had sufficient time to develop. Educators who attend workshops that are primarily designed for practitioners have the chance to improve their skills or learn new techniques while enjoying personal contact with those who work in the field on a daily basis. However, scholarship participants should not exceed 10% of the class enrollment; in situations where displacement of a paying student is likely, case-by-case considerations and decisions are warranted.

4. Using local site coordinators. Employing a local site coordinator is advisable in situations where the administrative and educational staff are not familiar with the facilities or locality. Site coordinators know the best training facilities, can occasionally obtain cheaper lodging rates than outsiders can, and are best able to recommend restaurants, transportation, and recreational services. They can often procure equipment, supplies, and replacement materials on short notice if needed. Using local site coordinators frees the instructional staff from administrative responsibilities so that they

can spend most of their time teaching. Site coordinators often volunteer their services; when they do not, they should be paid or tuition should be waived.

5. Minimum requirements for students and facility. Subject matter and format will dictate the classroom design and requirements. Advance arrangements must usually be made for audio-visual materials and other display equipment. Laboratory courses usually will require high seats or stools and approximately one square meter of table-top space per student.

The nature of the workshop will determine the criteria for student eligibility. Education, experience, and areas of specialization should be considered. Some workshops also might establish minimum requirements for applicant laboratories, for example, a requirement that the laboratory have certain essential equipment on hand or on order. By specifying such minimum equipment, the chances are enhanced that techniques learned at a workshop will be used by the student when he or she returns to the home laboratory. It is also useful to ask laboratory directors to certify beforehand who will pay the tuition (student or agency) and to assure that the student will be allowed time before the course to prepare for the workshop and on returning, will be allowed to use the newly learned skills, to brief others on the content of the course, and to complete any follow-up examinations.

6. Student enrollment. Moderate overbooking of students is advisable in order to meet course enrollment goals. Court appearances, personal problems, and the like will inevitabley result in some cancellations at the last moment. When possible, the use of a "list of alternates" is recommended, with these individuals informed in advance that they might be called to attend the workshop on short notice.

The issue of enrolling personnel who are not full-time crime laboratory practitioners might require action by the planning staff. In general, this practice must be judged on a case-by-case basis, but some suggested guidelines can be offered. If the course is geared to personnel from law enforcement agencies or is supported by government funds or both, displacement of law enforcement laboratory personnel should be discouraged. However, if room permits, students, educators and private-laboratory examiners should be permitted to attend the workshops. In many instances, the presence of personnel not affiliated with law enforcement agencies will enhance the flow of opinions to the advantage of all participants. It is also recommended that, in applicable situations, administrative and supervisory personnel be invited to attend the general introductory workshop lectures to foster better understanding between bench and administrative staffs and to bring administrators up to date on new techniques. Advisory board members should also be encouraged to attend at least a portion of the workshops. Generally students should be discouraged from auditing or sitting in on training workshops where they do not take examinations and participate in laboratory exercises.

C. Advertising the Workshop

The direct mailing of workshop announcements to potential participants is the method of choice for a successful workshop advertising campaign. Sources of mailing lists might include regional forensic science associations, the American Academy of Forensic Sciences, and professional journal and newsletter subscription listings. The second choice is the direct mailing of announcements to laboratory directors such as those belonging to the American Society of Crime Laboratory Directors (ASCLD).

A problem that might arise when using these lists is often the advertising sent to the laboratory director or administrator does not reach the potential, bench-level participant. This problem might be avoided by addressing the brochure to the Training Director or to the appropriate job classification designation, such as "Forensic Serologist" or "Document Examiner," in care of the laboratory. Another solution involves using multiple listings in professional newsletters, journals, or regional association mailings. The more intense the advertising saturation, the greater the potential enrollment. Advertising in other criminal justice publications such as newsletters published by NIJ, DEA, and private companies, in FBI bulletins and in the National Criminal Justice Reference Service's Selective Notification of Information Service (SNI) should be explored.

Lead times for various publications vary up to six months before the announcement is to appear so early planning is recommended. Getting the announcement to the editor as early as possible, even if exact dates and costs are not yet determined, is highly recommended. Many participants require between three months and six months to obtain permission to attend conferences or workshops.

D. Registration Forms

Tear-off brochures with the application attached to the announcement are suggested. Self-addressed post cards can also be used. Planners should see that all relevant information is included on the registration form, including the student's name, agency, address, telephone, job title, supervisor's name and title, education, years of experience, forensic science specialty area, previous training, choice of course, time, date, fee payment procedure, discount option, lodging request, director's priority certification and billing address. It should be clearly stated where and to whom the form should be mailed. One application form, with instructions to duplicate it for other registrants, is usually sufficient.

If announcements are mailed far in advance of a scheduled workshop or series of workshops, reminder notices should be sent to students shortly before the workshop begins.

E. Processing Applications

As the registration forms are received, they should be entered on a master data sheet that contains sufficient information to determine the status of any application at any time. The master data sheet should contain the title of the workshop, date, site, and instructor. Applicants should be entered in the order that applications are received, noting the date, the applicant's name, agency, state, and director's ranking designation. Additional columns should contain information regarding application submission, fee payment, equipment on hand, educational degree of the applicant, date that the application was received, acceptance, lodging requirements, deposit, billing, discount, and the like.

Although reservations can be accepted by telephone, applicants should be informed that they must submit written applications by a specified date. When an application is received, it should be acknowledged promptly in writing, using a post card stating that the application is complete or a form letter for applications that are incomplete that provides a check-off list for information needed to complete the registration. Prompt notification of acceptance increases the likelihood that agency clearance can be obtained, travel arranged, and court appearances rescheduled so that the applicant will be able to attend the workshop as planned. Applicants who are rejected should also be notified promptly.

Cancellations are inevitable, especially by those forensic scientists who are called on routinely to testify in court. However, workshop administrators may decide to levy a moderate penalty if cancellations are received less than one week before the workshop is scheduled. Usually a nonrefundable processing fee is included in the tuition. Substitution of applicants by laboratory administrators is acceptable if the substitute submits an application and meets all admission requirements.

F. Conducting the Workshops

So that students can arrive at the workshop prepared, reading and study materials should be sent to them approximately three weeks before the workshop begins. To increase their motivation to review these materials, students should be told that there will be an examination on the reading assignments on the first day of class.

Most workshops benefit from the use of audio-visual displays and handouts that are well conceived and designed. Many training facilities offer the audio-visual materials without charge or for a modest rental fee, but workshop planners cannot assume that this equipment will be available without making advance arrangements. Other aids, sometimes overlooked by planners, include a pointer, slide trays, overhead projector, microphone, projection screen, blackboard, flip chart, receipt book, name tags, marking pens, tape recorder, and tapes.

Standard hours for a workshop session are from 9AM to 5PM. If the logistics permit, 8 AM starting times should be encouraged. It is advisable to end classes slightly earlier on the final day so that students can make airport connections and hotel check-out times.

Some workshop facilities are accessible in the evenings--an option that should be considered when choosing a training site. Although evening sessions for students should remain optional, we highly recommended them for participants who require additional private instruction, or who wish to pursue a topic in greater depth than class time permits. The pre-workshop promotional literature should indicate whether evening sessions will be available.

G. Evaluation Procedures and Issuance of Certificates

Evaluation procedures may be divided into three types: those designed to monitor student performance, those relating to student satisfaction and comments, and those ascertaining the opinions of the staff and instructors.

The evaluation of student performance is primarily the responsibility of the instructional staff. Evaluation procedures can include quizzes, laboratory exercises, a final examination and the like. In courses designed to develop practical laboratory skills, follow-up proficiency tests should be administered after students return to their home laboratories. Both students and directors should know about these tests before the workshop begins, and a commitment allowing the use of laboratory equipment and time should be certified by the director at the time of registration.

At the completion of the workshop, students and faculty should be given the opportunity to express their opinions about the course. The use of a simple anonymous questionnaire is a practical means of collecting this feedback. The questionnaire might include items that utilize rating scales of student satisfaction, the degree to which the course met their needs, the usefulness of the course, and grading and evaluation procedures. Other items could ascertain whether the student would recommend the course, the best-and least-liked parts and suggestions for other topics for future workshops, and rating of the instructional staff. Space should be provided for additional comments. The completed surveys should be collected and tabulated by someone else besides the instructor if possible. The instructional staff should get a copy of the evaluation results. Most important, the need for confidentiality and security of all evaluation procedures should be stressed to both administrative and instructional staff.

Certificates should be awarded to those students who successfully complete all phases of the workshop. When follow-up proficiency tests are administered, certificates should be awarded only after the student submits and passes this portion of the training program. Certificates should state the name of the student, date, instructor, sponsoring agency, location of the workshop (when appropriate) and title of the course. It is sometimes advisable for a sponsoring organization to have a general training certificate printed that requires only the specific information relating to the workshop at hand be added to it, such as the name of the course, the instructor, and the date. This practice can substantially reduce the organization's printing costs comparred to the cost of printing a unique certificate for each workshop it sponsors.

CHAPTER V. FINDINGS AND RECOMMENDATIONS

A. General Findings

The scientists who attended the Forensic Microscopy Workshops were from diverse professional groups with educational backgrounds in forensic science, chemistry, biology, physics, and other natural sciences. A bachelor's degree was needed to enter the program; a significant number of students had master's and doctor's degrees.

Students exhibited a wide range of attitudes and motivation which proved to be major factors in how they approached the subject matter and how hard they were willing to work. Many saw the course as a unique opportunity to advance their forensic capabilities through an intense one-week effort with one of the most gifted microscopists in the world - Dr. Walter McCrone. Most students made an effort to derive maximum benefit from the course, devoting many hours to studying on site and to follow-up proficiency testing and further learning on returning to their home laboratories. Others were satisfied to come away with a heightened knowledge of the capabilities of the instrument and an appreciation for their colleagues accomplishments with the microscope, and perhaps with a "few tricks" to use at their laboratory bench. A veteran police officer who described the course as his "most intense experience since SWAT training", most clearly captured the intensity of the workshop, a feeling shared by most of his fellow participants.

The forensic science community benefited as a result of this training program. There is evidence of unprecedented interest in forensic microscopy by criminalists. Some regional forensic science associations have contacted the workshop teaching staff, hoping to schedule additional local workshops for their criminalists. An informal newsletter to discuss topics related to forensic microscopy is being established. The McCrone staff continues to talk with workshop graduates concerning problems they have encountered on case analyses and to supply guidance for particular microscopic examinations. Workshop graduates have begun to exchange samples of physical evidence (such as soils, hair, and furs) to expand their own standard reference material collections to increase their use of the polarizing microscope and the concepts learned at the workshops. Such positive benefits should continue to grow as graduates increase their confidence and capabilities in forensic microscopy. Conversations with graduates indicate many have performed successful analyses of materials that they could not have attempted before taking the workshops. Some have arranged internships with the McCrone Research Institute in order to continue their training in forensic microscopy.

Microscopy not only incorporates many of the techniques and principles of the natural sciences, but also constitutes a general problem solving approach to forensic problems. As such, it requires a special collection of skills and abilities not routinely developed in typical college or university science curriculums. A student who hopes to become a competent forensic microscopist by devoting a few weeks or months of study to the area is certain to face frustration and disappointment. Years of study and the opportunity to examine hundreds of samples of physical evidence likely to be encountered in an actual case are required. In this way the microscopist is constantly developing and refining skills and adapting them to both routine and unique forensic problems.

The point to be emphasized is that a one or two-week intensive course in forensic microscopy cannot transform the criminalist (generalist) into an accomplished forensic microscopist or cause a dramatic immediate increase in the use of forensic microscopy. What was accomplished at this series of workshops, however, was to heighten the examiners' awareness of the many capabilities and applications of

the polarizing microscope to solve problems associated with physical evidence. Basic procedures were presented and demonstrated with the hope that on returning to his or her home laboratory the student would practice and cultivate these skills to attain an even higher level of competency.

In addition to the examiners' lack of training, a second major obstacle to the widespread utilization of forensic microscopy in crime laboratories was detected by the McRI instructional staff during these workshops. Many microscopes brought by the students to the workshops for inspection were virtually unusable from either neglect or mishandling. Many students were unaware that their microscopes were not calibrated properly and they were unable to adjust them and put them back in working order. At the workshops these examiners learned how to adjust their microscopes properly and how to keep them in good working order. A well-trained examiner should be able to recognize and, in most cases, repair a faulty microscope, a favorable cost effective aspect of the microscope compared with more expensive and complex instrumentation in the crime laboratory that needs costly service contracts.

These Forensic Microscopy Workshops identified a nucleus of dedicated, enthusiastic, and highly motivated forensic examiners who should be afforded every opportunity not only to pursue their own advanced training in microscopy, but also to teach these skills to colleagues from their laboratories and geographical regions. These individuals are set apart from others in their profession--characterized by the teaching staff as possessing the attitude of a "scientist" rather than a "technician." The technician approaches a training program hoping to learn "cookbook" techniques instead of general skills that are adaptable to a wide range of problems. The "scientist" possesses the ability to conceptualize and apply general techniques to the diverse problems encountered in the forensic laboratory; the forensic sciences will provide them with continuing intellectual challenges and opportunities to display their creativity.

B. Recommendations

1. Continue training opportunities. The momentum generated by the Forensic Microscopy Workshops should be sustained through the support of additional training workshops at the advanced, basic, and fundamental levels*. This model of regionally based workshops has proven quite effective and would lend itself to continued training schedules for both introductory and special-topic presentations. Although the advanced courses in botanicals and soils and mineralogy were taught at one central location during this project, these courses could be taken "on the road" to the regional locations, an approach suggested by many students to encourage maximum participation.

Suggestions from laboratory directors and students point to the need to support a major portion of student travel and living expenses for the workshops, in addition to the basic cost of tuition. This arrangement, which proved successful for other NILECJ-funded training workshops, would permit smaller outlying laboratories to send their personnel to the workshops and would increase the overall level of participation nationwide. Funding for 80% of student travel and living expenses is thus strongly recommended.

Those students with the capability and interest should receive the special training needed to train co-workers in their home laboratories. Key individuals can be developed to become permanent training resources to provide instruction and technical assistance to their colleagues who are unable to attend training courses.

2. Updating the forensic microscopy workshops. It is imperative that participants in these workshops be afforded the opportunity to continue informal communications with other forensic microscopists and be provided ongoing training

*Fundamental courses would be designed for those criminalists who require only cursory microscopic training, such as serologists, questioned document examiners, and firearms/toolmark experts.

in microscopy. Thus we recommend that programs be supported-perhaps in conjunction with regional forensic science association meetings or the annual meeting of the American Academy of Forensic Sciences --to provide periodic update workshops and common-interest (round table) sessions for forensic microscopists.

3. Related activities. Training alone will never be sufficient to develop expert forensic microscopists. In conjunction with workshop and follow-up training, internships and sabbaticals are required to further develop the skills of crime laboratory personnel and allow them the opportunity to put aside their casework and pursue research in forensic microscopy. Without such opportunities, the skills and techniques learned in these workshops will stagnate and the students' potential will not be realized. We recommend a 50% time-sharing plan, whereby students could spend half their time learning new methods and preparing tables of optical properties and half their time on original research projects.

4. Support microscopy training at educational institutions. A federally supported suvey should be undertaken to identify those programs in forensic science and other fields at colleges and universities that provide microscopy training for students. Once identified, the better programs should be supported through student scholarships, internships, and programs to bring faculty up to date in current technology, so that they might be able to teach advanced technology to their students.

5. Phase II forensic microscopy workshops. The recommended fundamental microscopy course can adequately cover in one week or less the subject matter that the occasional users of the stereo, comparison, and light microscopes require. On the other hand, there is consensus of opinion among the workshop steering committee, project staff, and workshop instructors (and the majority of workshop graduates) that the basic workshop should be lengthned to two weeks.

Although it is recognized that this would require a corresponding increase in tuition and other expenses, it is deemed necessary. The one-week, advanced, special-topic courses, which would be offered to each region during the proposed second phase of training, should continue unchanged. A proposal for a one-year 20-workshop program is presented below. Fundamental courses for the causal user are not included in this proposed schedule.

Ten basic courses will be taught in designated geographical areas in the United States, and ten advanced courses will be taught in Northern California, in the New York City Metropolitan Area, and in the Atlanta area. In each advanced--course location, 3 courses would be taught, including botanicals, soils, and explosives and explosives residue. In addition, there would be one advanced course in Chicago--the advanced explosives and explosives residue workshop which has not be presented there previously. A drug identification course is also badly needed but would require at least a year to prepare, and thus is not included in this proposal. Many of the project costs would essentially remain the same as for the current program. Costs for travel, laboratory supplies, and training materials would not increase substantially. In the proposed program, salaries for instructional staff would be increased to conform to the proposed two-fold increase in teaching time. Excluding the recommended 80% support of student travel, the estimated budget increase for the sub-contracted instructional services of McRI for a second year is conservatively estimated at approximately $17,000 above the just completed cyle--$108,300 versus $91,038. These estimates will be modified on the basis of changes in the program.

To support 80% of student travel and per diem for 350 students (175 in the two-week basic workshops and 175 in the one-week advanced courses), an increase in

funding of approximately $101,500 will be required, as follows:

Travel	
Transportation	
$100 x 350 students x 80% =	$28,000
Per Diem	
$25/day x 14 days x 175 students x 80% =	$49,000
$25/day x 7 days x 175 students x 80% =	$24,500
TOTAL TRAVEL COSTS (80%) =	$101,500

The total cost of conducting this second phase of the Forensic Microscopy Workshops would be $108,300 for McRI services, $101,500 to cover 80% of student travel, plus FSF administrative costs. The cost of a fundamental course for occassional users of the microscope is <u>not</u> included in the estimates noted above.

APPENDIX A

THE FORENSIC SCIENCES FOUNDATION, INC.

11400 ROCKVILLE PIKE • ROCKVILLE, MARYLAND 20852 • (301) 770-2723

TO: Crime Laboratory Directors

FROM: Joseph L. Peterson and Ira T. Silvergleit

SUBJECT: Microscopy Workshops

The Forensic Sciences Foundation, Inc. is pleased to invite your participation in our recently awarded Forensic Microscopy Workshops training project funded by the NILECJ/LEAA. This grant will enable us to conduct twenty (20) regional one-week workshops in forensic microscopy throughout the United States over the next twelve months. The main objective of the project is to provide basic and advanced special topics instruction in the application of microscopy to the examination of various types of physical evidence. The proposed curriculum (see Attachment A) of these workshops is unique and is not available at or planned by other agencies or instructional sources (such as the F.B.I.). Other objectives of the project are to provide a "state-of-the-art" monograph of forensic microscopy and to develop a general training methodology and evaluation procedure adaptable to future training projects in the forensic sciences.

On-site instruction will be provided at various locations by the McCrone Research Institute of Chicago, Illinois in consultation with a nationally selected Workshop Steering Committee (WSC) composed of individuals who are authorities in forensic microscopy and who also represent each regional division of the nation. In addition, regional site coordinators to be selected by the WSC will assist in the selection of suitable workshop locations and in the instructional process.

Sixteen (16) workshops over a period of twelve months will cover basic forensic microscopy, emphasizing the use of the polarizing microscope. There will also be two (2) advanced workshops on each of the following topics:

1) Wood, pollens, paper, pulp and plant fibers, and

2) Soils and minerology.

Grant administered by the Forensic Sciences Foundation, Inc.
For the National Institute of Law Enforcement and Criminal Justice
Law Enforcement Assistance Administration
United States Department of Justice

These two courses will be given at the McCrone Research Institute, Chicago, Illinois and be open to students successfully completing the basic microscopy workshop or its equivalent. Each advanced course is scheduled twice, one midway through the funding period (in early December 1978) and once towards the end of the period (April 1979). The tentative regional workshop schedule is contained in Attachment B. Final selection of workshop sites will be based on need and local interest as expressed through student enrollment and in consultation with regional representatives. The workshops begin Monday morning and end Friday afternoon.

The grant covers 80% of the cost of instruction. The student (or agency) is only responsible for payment of the remaining 20% of the training costs amounting to $65, plus transportation expenses, meals and lodging. The $65 tuition is due no later than the first day of class and is payable to "McCrone Research Institute".

Laboratory Requirements

In order to insure the successful transfer of technology to students, and that skills once learned are incorporated into the working routine of the home laboratories, laboratory directors are asked to certify that those personnel selected for the training workshops be allowed sufficient work time to prepare in advance of the workshops to complete:

a) workshop readings, and

b) assessment examinations, and

allow sufficient time upon returning from the training workshops to:

a) complete follow-up bench tests,

b) incorporate the new techniques into laboratory procedures and

c) formally communicate newly learned skills to laboratory co-workers, especially those who were recommended for but not selected to attend the workshops.

Furthermore, in order to be eligible for the training program, the laboratory director must declare that equipment necessary to incorporate the training methodologies into the laboratory routine, specified in Attachment C, be currently available or "on order" at the home laboratory.

Student Selection Criteria

Applicants must hold at least a Baccalaureate Degree in chemistry, physics, biology, biochemistry, forensic science, medical technology or an equivalent preparation. Previous experience in microscopy is recommended but not required. They must be willing to prepare assignments in advance of the training workshop, to participate in several classroom examinations and in follow-up bench testing upon completion of the training, and to formally communicate the new techniques to fellow microscopists at their home laboratory. Individual examination scores will be treated confidentially.

Upon successful completion of the microscopy training workshop and submission of follow-up bench tests and course evaluations, the student will receive a certificate of completion.

Application Procedure

Submit a separate application for each individual recommended for the program. One application form is enclosed and may be duplicated as needed. On each application in the space provided, rank each applicant according to your preference for his or her taking the course as compared to the others you have recommended. Use the rank "one" for your first preference, etc. If only one application is submitted, rank the person "one". Those applicants without a ranking will receive the lowest priority for selection. Have each applicant complete the enclosed pre workshop examination. This assessment mechanism is for informational purposes only and will not affect selection or course grading of the applicant. Each applicant should complete the examination on his or her own, without the aid of written information or consultation with others. Duplicate the enclosed examination as required.

One student per laboratory will be admitted before additional students from that laboratory. Subsequent personnel will be admitted as space permits. Final determination of eligibility and admittance is the responsibility of the Forensic Sciences Foundation, regional representatives and the WSC.

Complete and sign the application form stating that necessary equipment is or will be available and that the student will be allowed time both before and after the workshops to prepare for and complete the requirements of the training. If a specific workshop location and date is not indicated on the workshop schedule (Attachment B), would you please suggest a workshop site preference and preferred dates. Final selection is the responsibility of FSF, regional representative and the WSC.

Mail the completed application (Parts I and II) and examination to:

The Forensic Sciences Foundation, Inc.
11400 Rockville Pike, Suite 515
Rockville, Maryland 20852
Attn: Ira T. Silvergleit, Project Director

NOTE: DUE TO TIME LIMITATIONS AND LIMITED SPACE, PLEASE RETURN THE ABOVE MATERIALS AT LEAST ONE MONTH IN ADVANCE OF THE WORKSHOP(S) APPLIED FOR. IF YOU ARE UNABLE TO RETURN THE REQUIRED PAPERWORK BY THAT TIME, PLEASE CALL THE FORENSIC SCIENCES FOUNDATION (COLLECT) IN ORDER THAT PLACES BE RESERVED FOR YOUR STUDENTS.

Enclosures: Memo from Dr. McCrone
Student Application (Part I)
Student Application (Part II)
Pre Workshop Assessment Examination
Attachments A, B, and C
Forensic Microscopy Workshop Steering Committee

MEMO TO: Crime Laboratory Director

FROM: Walter C. McCrone

SUBJECT: Forensic Workshops in Polarized Light Microscopy

The McCrone Research Institute has signed a subcontract with the Forensic Sciences Foundation under their LEAA contract to teach 20 forensic workshops during the period June 7, 1978 - June 6, 1979. Each workshop will train 15-20 criminalists the proper use of the polarizing microscope and how to characterize the various trace evidence types (glass, hair, fibers, paint, soils, drugs, insulations, explosives, dust, gunshot residue, metals, etc.).

We have found that the person who receives the greatest benefit from this course is the one with most background in microscopy. Conversely, a complete greenhorn will probably be badly snowed. We try to help increase each applicant's background by sending him the course manual with specific reading and study assignments as soon as his application is approved. We urge you, therefore, to expedite these applications as much as possible.

It is important for you, as Laboratory Director, to be aware that microscopy is a skill which, like tennis or playing the piano, requires continued practice and use. We require that the applicant have a polarizing microscope available (on hand or on order) and we ask that you cooperate in allowing time for application of the techniques he will learn during the workshop. His usefulness in applying microscopy will be directly proportional to the time he is able to spend with the microscope. In a short time he will easily make up that time investment by better and faster trace evidence examinations.

When he returns from the workshop he may also need additional equipment. The following list may prepare you; again, we hope you will cooperate in this. The cost is surprisingly low considering any other crime lab equipment and especially considering the general usefulness of the polarizing microscope in the crime lab.

Polarizing microscope	$ 900 -	$ 5,000
Stereobinocular microscope	500 -	5,000
Camera	454 -	968
Illuminator	150	
Cargille refractive index liquids	174 -	600
Cargille reagent sets	85 -	170
Slide storage cabinet	115 -	220
Hot stage	600 -	4,500
Dispersion staining objective	240	

Reference slides			
Spermatazoa	(40)	$ 90 -	$ 180
Particle reference set	(100)	160	
Fiber reference set	(100)	245	
Paint pigment reference set	(50)	115	
Minerals reference set	(150)	250	
Animal hairs reference set	(50)	80	
Fiber reference set	(50)	80	
Books and journal (<u>The Microscope</u>)		100 -	300
<u>Particle Atlas</u>		240 -	360
	TOTAL	$4,578 -	$ 17,298

LEAA is especially interested in upgrading crime lab personnel and measuring the upgrading process. To do this the applicants are asked to complete an examination as a part of their application. They will also have a number of homework quiz assignments during the course, several short practical exams during the week, a final written and a final practical bench test on the last day and several months later a practical bench test that may require up to 4 hours to complete.

You now know what you and your workshop applicants are up against; we hope you will still take advantage of the program.

WCM:km

The Forensic Sciences Foundation, Inc.

11400 ROCKVILLE PIKE
ROCKVILLE, MARYLAND 20852
(301) 770-2723

STUDENT APPLICATION FORM (PART I)
FORENSIC MICROSCOPY WORKSHOPS

To be completed by Laboratory Director.

DIRECTIONS: Please use a separate application form for each student applicant. Duplicate this form as necessary.

Applicant's Name: ______________________________
Last First Middle Initial

Director's Name: ______________________________
Last First Middle Initial

Laboratory Address: ______________________________
____
____

Telephone Number: ( ) ________________

Course(s) Desired:
___ Basic
___ Advanced I - Wood, Plants
___ Advanced II - Soils, Mineralogy

Workshop Site Preference:
Region ________________
State ________________
Facility ________________

Date Preference:
1. Week of ________________, or
2. Week of ________________

Rank this applicant relative to others you have recommended. ________

Total number of persons from your laboratory you have recommended: ________

- OVER -

Laboratory Director's Statement

I agree to allow those persons selected for these workshops to prepare advance materials/assignments and to complete follow-up bench tests and evaluations. Furthermore, the required equipment is available in my laboratory (or on order). Graduates of the program will be given sufficient time within the constraints of workload considerations, to practice, evaluate, and incorporate techniques learned at the workshops into their laboratory routine, and formally communicate these methods to other interested laboratory personnel.

The $65 cost of tuition will be payed by:
__ the individual student (s).
__ this agency.

____
Laboratory Director's Signature

____
Date

The Forensic Sciences Foundation, Inc.

11400 ROCKVILLE PIKE
ROCKVILLE, MARYLAND 20852
(301) 770-2723

STUDENT APPLICATION FORM (PART II)

FORENSIC MICROSCOPY WORKSHOP

To be completed by each student applicant.

DIRECTIONS: Each student must submit a separate application. Duplicate this form as necessary.

Applicant's Name: ______________________________
Last First Middle Initial

Laboratory: ______________________________
Name City State

Highest Degree Completed ______________ Major Field ______________

School and Date ______________________________

My academic specialties were: ______________________________

I have taken other specialized training as follows: ______________________________

____

My professional experience includes:

Dates	Place	Job Title
1.		
2.		
3.		
4.		

My forensic specialty areas are (hair, glass, trace evidence, etc.) ______________

____

I am now, and expect to continue in the future as a practicing forensic scientist. Yes________, No________

Have you used a light microscope more than casually? ______________

What types (underline with a double line for more than casual use):
Stereobinocular, comparison, biological, polarizing, fluorescent, reflecting, phase, interference, other: ______________________________.

- OVER -

Have you had previous basic microscopy training? ______Yes, ______No

If Yes, where? ______________ McCrone Institute

______________ Other (specify) ______________

____

____

I will bring the polarizing microscope to the course for evaluation, cleaning, and adjustment or recommendations for upgrading or replacement. Yes________, No________.

I am willing to read and study the introductory portions of the course manual to be sent to me before the course and to take a written examination on this assignment on the first day of the course. Yes________.

I am willing to complete additional tests based on the course curriculum 1-2 months after the course is completed. Yes________.

Experience:

I have been a forensic scientist for ________years.

Of this time (above), how many years have you spent actually working "at the bench"? ________years

My principal interests in forensic science are: ______________________________

______________(minor): ______________________________

I acknowledge that I am responsible for payment of my own travel and per diem expenses in addition to a fee of $65. The latter to be paid to MRI is due no later than the first day of the course.

______________Agreed (please initial)

PLEASE PRINT

My name is: ______________________________

Address: ______________________________

____

Signature: ______________________________

Date: ______________________________

ATTACHMENT A

McCrone Research Institute

FORENSIC MICROSCOPY
(tentative)

Monday: (Reading Assignment: MRI Course Manual* — pp 1-41, 94-123, 205-208)

Lecture: Introduction, brief history of forensic microscopy, physical optics, types of microscopes useful in criminalistics, polarizing microscope, illumination, micrometry.

Laboratory: Familiarization with the polarizing microscope and illumination, micrometry, study of human hair diameter and scale count.

Lecture: Crystal morphology: systems, axes, forms, habit, symmetry; microchemical reactions.

Laboratory: Recrystallization from vapor and solution on a microscope slide; microchemical tests.

Tuesday: (Reading Assignment: pp 124-140, 164-189)

Lecture: Crystal Optics I: polarized light; refractive index and variation with atomic number, wavelength and temperature.

Laboratory: Measurement of refractive indices for isotropic and anisotropic substances, double variation method.

Lecture: Dispersion staining.

Laboratory: Applications of dispersion staining**: textile fibers, hair, mineral wool, glass, drugs, explosives, soil minerals.

Wednesday: (Reading Assignment: pp 141-163, 205-208)

Lecture: Crystal Optics II: retardation, birefringence, compensators, interference figures.

Laboratory: Study of fibers, birefringence and sign of elongation; conoscopic observations.

Lecture: Characterization and identification of small particles (biological, mineral, industrial and combustion products)

Wednesday (continued)

Laboratory: Study of known particles.** (soils, fibers, hairs, inorganic explosives).

Thursday: (Reading Assignment: pp 190-199)

Lecture: Sampling methods, preparation methods, supplementary methods (squoosh test, staining, magnet, density, crystal-rolling), particle classification.

Laboratory: Identification of unknowns.** (textile fibers, hair, mineral wool, glass, drugs, explosives, soil minerals).

Lecture: Visual thermal analysis, characterization of drugs and explosives, polymorphism and composition disgrams.

Laboratory: Study of organic explosives and drugs.

Friday:

Lecture: Special methods (phase, fluorescence, SEM, TEM, XRD, EMA, IMA), particle fractionation, isolation, manipulation); microminiaturization of tests and measurements; photomicrography.

General discussion and questions: sources and resources, microscopes and accessories, standard methods, standard reference materials; proficiency tests, certification and accreditation.

The course is over about lunchtime.

* The course manual will be sent to students at least one week before the course begins.

** Each student may elect one of the listed forensic evidence types for study.

The course will include about 10 hours of lecture, 15 hours of lecture-demonstration, 5 hours of guided laboratory use of the microscope and 16 hours of independent laboratory exercises. The course hours will be officially 8 a.m. - 5 p.m. Monday - Thursday and 8 a.m. - noon on Friday with additional laboratory work optional. The course outline includes about 6 elective hours in the forensic area of direct interest but limited to hair, other fibers, microchemical methods, soils, glass, safe insulation, drugs, dust analysis, explosives or paint. Subsequent proficiency tests will include each student's elected specialty.

ATTACHMENT B

WORKSHOP SCHEDULE
(Tentative)

Location	Dates
1. Atlanta, Georgia	June 26-30, 1978
2. Raleigh, North Carolina	July 17-21, 1978
3. Washington, D.C.	July 31- Aug. 4, 1978
4. Storrs, Connecticut	Aug. 20-26, 1978
5. Chicago, Illinois	Sept. 25-29, 1978
6. London, Ohio	Oct. 23-27, 1978
7. Denver, Colorado	Nov. 6-10, 1978
8. Seattle, Washington	Nov. 27-Dec. 1, 1978
9. Advanced I - Wood (Chicago)	Dec. 11-15, 1978
10. Advanced II - Soils (Chicago)	Dec. 18-22, 1978
11. Modesto, California	Jan. 15-19, 1979
12. Los Angeles, California	Jan. 22-26, 1979
13. Phoenix, Arizona	Feb. 26-Mar. 2, 1979
14. Austin, Texas	Mar. 5-9, 1979
15. Shreveport, Louisiana	Mar. 19-23, 1979
16. Southeast	Mar. 26-30, 1979
17. Advanced I - Wood (Chicago)	Apr. 9-13, 1979
18. Advanced II - Soils (Chicago)	Apr. 16-20, 1979
19. Mid Atlantic - Baltimore, MD.	Apr. 30-May 4, 1979
20. Storrs, Connecticut	May 21-25, 1979

THIS SCHEDULE IS SUBJECT TO CHANGE.

ATTACHMENT C

EQUIPMENT/SUPPLIES REQUIREMENTS

Minimum Specifications for a Polarizing Microscope

1. Monocular upright bodytube
2. Rotating stage (or simultaneously rotating polars)
3. Either stage or objectives must be centerable (but not both)
4. Focusable ≥ 0.9 NA condenser capable of Köhler illumination for all objectives
5. Three achromatic objectives, one in each of the ranges: 3.5-6.3X, 8-12X and 40-50X; they must be parfocal
6. ≥ 10X ocular, focusable eyelens with crossline graticule
7. ≥ 8X ocular, focusable eyelens with micrometer graticule (the crossline and the micrometer scale may be combined in a single graticule in a single ≥ 10 ocular)
8. Bertrand lens
9. Mirror
10. Red I compensator and compensator slot

Laboratories must have a minimum set of refractive index liquids covering the range from $n_D = 1.400 - 1.700$ with, at least, 0.004 intervals.

Minimum Specifications for Microscope
Illuminator (Built-In or External)

It must be possible to achieve good Köhler illumination with all objectives and any ≥ 0.9 NA condenser. This requires the ability to focus a clear image of the lamp filament in the plane of the substage aperture diaphram as determined by observing its conjugate focus, the objective back focal plane, with the Bertrand lens.

The following equipment is required:

1. Clear bulb
2. Compact filament, ideally a square array 2-3 mm on edge with closely spaced filament wires
3. Centerable bulb

4. Lamp condenser lens diameter of $\geq$ 40 mm
5. Lamp iris covering full lamp condenser lens aperture
6. Lamp condenser to filament distance continuously variable to permit focusing a sharp image of the filament 10-40 cm in front of lamp
7. Lamp capable of x, y, and z movement
8. Diffuser, if present, removable
9. Clear daylight blue filter
10. Filter holder
11. Field diaphram should not change its position when the filament focus is changed

Desireable Additional Microscope Features

1. Inclined bodytube
2. Binocular bodytube
3. Trinocular bodytube
4. Ball-bearing rotating stage
5. Spring-mounted objective front lens
6. 0.85 NA 40-60X objective
7. 100X oil immersion objective
8. Better corrected objectives: fluorites, apochromats or planapochromats
9. 15-20X ocular
10. Built-in Köhler illumination
11. Centerable substage condenser
12. Quarter-wave plate
13. 3-4 order variable retardation compensator
14. Interference filters for F, D, and C lines
15. Rotating nosepiece
16. Centerable focusable Bertrand
17. Neutral density filters (0.1, 0.3, 0.7)
18. High-eyepoint oculars
19. Wide-field oculars

COURSE MATERIALS
(Provided By McCrone Research Institute)

A. Each student and the instructor will have:

1 Olympus POS microscope
1 Olympus LSD illuminator
1 Course manual
1 Set of 100 prepared slides
1 Dispersion staining objective
1 Stage micrometer
1 Set of solvents and Aroclor 1260
1 Notebook
1 Set of manipulative tools
1 Box of slides and coverslips

B. Each pair of students will have:

2 Reagent and sample blocks
1 Set saturated aqueous solutions
1 Alcohol lamp

C. There will also be:

1 Closed circuit TV system
1 Public address system and lectern
1 Carousel slide projector
1 Set of refractive index liquids 1.3-1.8
1 Set of high dispersion index liquids 1.5-1.65
1 Oil immersion objective & bottle of immersion oil
2 Quartz wedges
1 Olympus 35 mm photomicrographic camera
1 S & M exposure meter
1 Set of tools
1 Tiyoda microscope
1 McArthur microscope
1 Mettler hotstage
1 100-fiber reference set
1 20-slide animal sperm set
8 Cargille sets of prepared slides
1 Library of reference books
1 Hot plate
2 Aroclor 5442

Each student may bring his (or his laboratory's) polarizing microscope for evaluation, cleaning, adjustment and recommended upgrading or replacement. McCrone Research Institute (MRI) will furnish up to 25 complete polarizing microscopes as well as all visual aids and course materials.

CONTINUED

1 OF 2

The Forensic Sciences Foundation, Inc.

11400 ROCKVILLE PIKE
ROCKVILLE, MARYLAND 20852
(301) 770-2723

Forensic Microscopy Workshop Steering Committee

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APPENDIX B

PRE-WORKSHOP ASSESSMENT EXAMINATION

NAME:________________________

LABORATORY:____________________

Why do you wish to take this course?

The following questions will have no bearing on your acceptance for this course and are included only as an evaluation of your present level in the areas to be covered in this course. Please answer as best you can.

1. The double variation procedure is most often used to evaluate soils microscopically. True_______ False________

2. Birefringence and retardation are synonymous. True_____ False_____

3. Write out balanced chemical equations for the beryllium microchemical test giving tetragonal basal plates of the octahydrate of the chloroplatinate:____

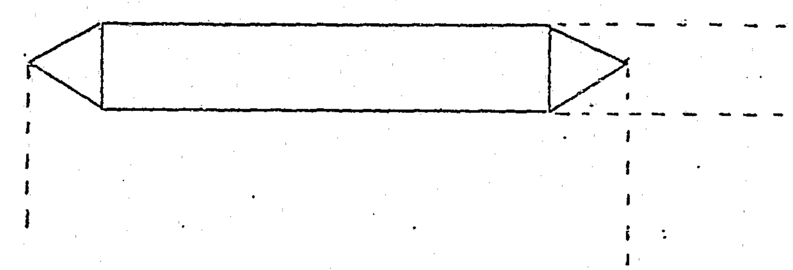
and the test for silver using metallic zinc as a reagent:

____

4. Melting points can be measured reproducibly and accurately to ±0.1°C with a microscope hotstage. True______ False________

- OVER -

5. Complete this orthographic projection of a tetragonal crystal (2 views):



6. The dyes used for dispersion staining have unusually strong dispersion. True______ False_______

7. The polarizing microscope can be used to characterize, compare and identify (cross out negative answers): glass? hair? fibers? paint? drugs?

8. A scientific basis for forensic microscopy is Edmond Locard's "Exchange Principle". True_____ False_____

9. There is no magnification limit for light microscopy. True______ False_____

10. List as many microscopically measurable parameters of small particles as you can:____

____

____

____

I have (or will have by __________) the following polarizing microscope and accessories in useable condition (include details of type of microscope, illuminator, monochromator, hotstage, index liquids etc.)_____________

____

____

____

APPENDIX C

Course Outline

Forensic Trace Evidence Microscopy

This course is planned as a basic course in polarized light microscopy for the trace evidence examiner in the crime lab. It will not be directly useful to blood and body fluid, imprints or firearms and toolmark examiners and only marginally useful to document examiners. It will cover the polarizing microscope — optics, adjustment and cleaning; illumination — how to obtain the best possible visible and photomicrographic images; identifying characteristics of small particles — size, shape, surface, color, homogeneity, transparency, refractive indices, dispersion etc.; and the application of these tools and techniques to the characterization, comparison and identification of trace evidence: paint, fibers, soil, glass, hair, explosives, drugs etc.

The course manual is sent to the students one to two weeks before the course and they are expected to read as much as possible starting with Optics (p.3-14), Compound Microscope (p. 15-26), Resolving Power and Illumination (p. 27-41), Polarized Light and Interference (p. 49-53), Photomicrography (p. 69-94), Micrometry and Counting Analyses (p. 95-105), Crystal Morphology (p. 108-124), Microchemical Tests (p. 206-210), Crystal Optics, one polar (p. 125-142), Dispersion Staining (p. 169-196), Crystal Optics, crossed polars (p. 146-168), Hotstage Methods (p. 197-205), Morphological Analysis (p. 211-214).

If the reading assignments are not completed by classtime, the pertinent sections must be read before that material is covered in class. The following schedule indicates when each section will be covered. Each student will have his own Olympus POS polarizing microscope with all needed accessories. Each subject will be covered by lecture, lecture-demonstration and appropriate laboratory exercises.

Monday, 8 a.m. - 5 p.m. (Reading Assignments: p. 3-41, 69-124, 206-210)

Lecture: Physical optics, polarizing microscope, illumination, micrometry, photomicrography.

Laboratory: Familiarization with the polarizing microscope, practice in Köhler illumination, calibration of ocular micrometer, measurement of hair diameter and scale counts

Lecture: Crystal morphology: lattice, axes, faces, systems, symmetry, forms, habit; microchemical tests; recrystallization procedures

Laboratory: Recrystallization from vapor, solution, evaporation and cooling), melt and by precipitation; selected microchemical reactions (procedures, pages 225-227,234).

Tuesday, 8 a.m. - 5 p.m. (Reading Assignment: p. 49-53, 69-94, 125-142, 169-196)

Lecture: Crystal Optics I (polarizer only): refractive index and variations with temperature and wavelength. Isotropic vs anisotropic solids

(over)

Laboratory: Measurement of refractive indices of isotropic and anisotropic substances (procedures, pages 228-229)

Lecture: Dispersion staining

Laboratory: Determina tion and application of dispersion staining data (procedures, pages 229-230) to glass chips or fibers and crystalline substances

Wednesday, 8 a.m. - 5 p.m. (Reading Assignment: p. 146-168, 211-214)

Lecture: Crystal Optics II (crossed polars): birefringence, retardation, compensators

Laboratory: Study of fibers: birefringence, sign of elongation etc. (procedures, pages 232-233)

Lecture: Interference figures, correlation of optical and morphological data

Laboratory: Study of interference figures

Lecture: Visual thermal analysis: melting points, crystal-front from the melt (form, growth rate, birefringence, extinction, phase transitions etc.), applications to drugs and explosives

Laboratory: Study of the methods of visual thermal analysis, characterization and identification of drugs and explosives (p. 236)

Thursday, 8 a.m. - 5 p.m. (Reading Assignment: p. 197-205)

Lecture: Collection, fractionation, manipulation and identification of small particles, study of dust particles (animal hair, plant hairs, vegetable fibers, starches, pollens and paper fibers

Laboratory: Study of known and unknown particles

Lecture: Microscopical Characterization of Trace Evidence

Laboratory: Study of trace evidence

Friday, 8 a.m. - noon

Lecture: Special methods of small particle characterization - XRD, SEM/EDXRA, EMA, TEM, IMA, EMMA, LRMA (MOLE)

General discussion: microanalytical methods, training, standard reference materials, certification, societies, books, courses, meetings etc.

Final practical examination: characterization and identification of the components of an unknown mixture

Final written examination

Course critique

Minimum Specifications for a Tungsten Filament Microscope Illuminator

It must be possible to achieve good Köhler illumination with all objectives. This requires 1) the ability to focus a clear image of the lamp filament in the plane of the substage aperture diaphram as determined by observing its conjugate focus (objective back focal plane) with the Bertrand lens; 2) that the image of the filament fill the full objective aperture; and 3) the ability to focus a clear image of the field diaphram (lamp iris) centered in the plane of the preparation. To do this will require:

1. clear (unfrosted) bulb
2. compact filament, ideally a square array 2-3 mm on edge with closely spaced filament wires
3. centerable bulb (on lamp condenser axis)
4. lamp condenser lens diameter of ≥40 mm
5. lamp iris covering full lamp condenser lens opening
6. lamp condenser to filament distance continuously variable to permit focusing a sharp image of the filament 10-40 cm in front of lamp
7. field diaphram should not change its position when the filament focus is changed
8. lamp capable of x, y and z movement
9. diffuser, if present, easily removable
10. clear daylight blue filter
11. filter holder
12. variable voltage control

Minimum Specifications for Stereobinocular Microscopes

Two independent identical optical paths, one for each eye.
Interocular distance continuously variable from 55-70 mm.
One independently focusable ocular.
One ocular with micrometer scale (focusable tops lens ocular).
Total magnification range 5-100X with at least 4 magnification steps.
Numerical aperture at highest magnification ≥0.13.

Desirable Additional Features

Transmitted light capability.
Zoom optics.
Trinocular bodytube.
Higher top magnification, e.g., 150-200X.
Concave front surface objective lens acting as a Lieberkuhn illuminator (brightfield top light by reflection of transmitted light back onto opaque specimens; see PA* II, Vol. I, pp. 239).
Universal stand to permit extension over large samples.
Easily offset optics for straight-through photomicrography.
Polars with rotating stage.
Aperture diaphram in the body tube.

*Particle Atlas, Ann Arbor Science Publishers, Ann Arbor, Michigan

Minimum Specifications for a Polarizing Microscope

1. Monocular upright bodytube
2. Rotating stage (or simultaneously rotating polars)
3. Either stage or objectives must be centerable (but not both)
4. Focusable ≥ 0.9 NA condenser capable of Köhler illumination for all objectives
5. Three parfocal achromatic objectives, one in each of the ranges: 3.5-6.3X, 8-12X and 40-50X
6. ≥10X ocular, focusable eyelens with crossline graticule
7. ≥8X ocular, focusable eyelens with micrometer graticule (the crossline and the micrometer scale may be combined in a single graticule in a single ≥10 ocular)
8. Bertrand lens
9. Mirror for external illuminator
10. Red I compensator and compensator slot

Desirable Additional Features

1. Inclined bodytube
2. Binocular bodytube
3. Trinocular bodytube
4. Ball-bearing rotating stage
5. Spring-mounted objective front lens
6. 0.85 NA 40-60X objective
7. 100X oil immersion objective
8. Better corrected objectives: fluorites, apochromats or planapochromats
9. 15-20X ocular
10. Built-in Köhler illumination
11. Centerable substage condenser
12. Quarter-wave plate
13. 3-4 order variable retardation compensator
14. Interference filters for F, D and C lines
15. Rotating nosepiece
16. Centerable focusable Bertrand
17. Neutral density filters (0.1, 0.3, 0.7)
18. High-eyepoint oculars
19. Wide-field oculars

3/79

OLYMPUS 35-mm CAMERA

Check List

1. Lamp on 6 V and with daylight filter (blue).

2. Focus crosslines in side-viewing telescope.

3. Check for Köhler illumination.

4. Focus on prep

   a. field diaphram centered (mirror) and focused (substage condenser ↑↓)

   b. fully illuminated objective back focal plane (aperture diaphram open, filament in focus).

5. Set beam splitter on yellow line and read light meter with polarizer in but no analyzer:

   multiply meter reading (EMR) on scale 1 by 1000
   " " " " " " 2 " 100
   " " " " " " 3 " 10
   " " " " " " 4 " 1.

6. Return beam splitter to green line before shooting.

7. For crossed polars shots use K = 200 (ASA = 160); $\frac{K_{ASA}}{K_{160}} = \frac{160}{ASA}$

   where K = EMR x Exposure Time (sec)

   For one polar use K = 75

   Exposure Time = K/EMR.

8. Bracket the exposure time; (x 2 and x 0.5).

9. Set exposure time.

10. Cock shutter.

11. Release shutter.

12. Depress button (under exposure number window) on camera and release immediately.

13. Advance film (turn large knob on camera to a stop).

14. Record data.

MINERAL IDENTIFICATION KEY

ISOTROPIC
- *INDEX > 1.66 (Aroclor)*
  - *Excellent cleavage n_D = 2.37, may be colored.* . . . . . . *Sphalerite*
  - *Conchoidal fracture n_D ca 1.74-1.80, may be colored, sl. anisotropic, blue-black borders.* . . *Garnet*
- *INDEX < 1.54 (Canada balsam)*
  - *Octahedral cleavage* . . . . . . *Fluorite*
  - *Conchoidal,*
    - *Clear, vesicular air bubbles, "fire-polished"* . . . . . . *Pumice*
    - *Translucent, rough surface* . . . . . . *Opal*

ANISOTROPIC
- *INDICES > 1.66 (Aroclor); little or no color*
  - *Good cleavage*
    - *Square-ended blades tricl. (-) 2V = 82-83°, stepped ends, 1.715-1.73.* . . . . . . *Kyanite*
    - *Flake habit, monocl. (+) 2V = 14-90° r<b; anom. blue-green 1st order white.* . . . . . . *Clinozoisite*
  - *Rounded*
    - *n's ≫ 1.66 tet. (+) ω ca 1.94, ε ca 1.98 mod. biref.; sometimes euhedral.* . . . . . . *Zircon*
    - *n's ca 1.77 uniaxial (-) low biref.* . . . . . . *Corundum*
    - *n's ca 1.75 biaxial (+) 2V ca 85° r>b* . . . . . . *Staurolite*
- *INDICES > 1.66 (Aroclor); colored*
  - *Red and yellows, v. high n's*
    - *Tet. (+), 2.6-2.9, conchoidal fracture or sand grains, yellow to red-brown pleochroism.* . . *Rutile*
    - *Hex. (-), 2.9-3.2, conchoidal fracture, very fine, deep reds only* . . . . . . *Hematite*
  - *Deep greens and blues*
    - *Flat blades of clear green, higher n darker green, n's sl. > to > 1.66; pleochroism, high 2V (+)* . . . . . . *Hornblende*
  - *Green to red pleochroism*
    - *If not too colorless to show; n's sl. > 1.66 (-) r>b like tremolite but ∥ extc. and higher n's* . . . . . . *Hypersthene*
  - *Pale green to colorless*
    - *Monocl. n's 1.66-1.69 (+) r>b* . . . . . . *Diopside,*
      diff. to differentiate, Diopside 2V = 50-62°, Augite 25-83° *Augite*
    - *n's 1.72-1.74 monocl. (-) 2V = 74-90° pleochr. like diopside* . . . . . . *Epidote*

- *INDICES 1.54 (Canada balsam) - 1.66 (Aroclor)*
  - *Colored*
    - *Polycrystalline, different shades of yellow green-green n's 1.60-1.62, (-) low 2V perfect basal cleavage* . . . . . . *Glauconite*

(OVER)

Colorless

V. high birefringence

rhombohedral cleavage, (-) sign . . . . Calcite

ω = 1.658, ϵ = 1.486. . . . . Dolomite

ω = 1.68, ϵ = 1.50 . . . .

Indices sl. < 1.66

Uniaxial . . . . Apatite

Conchoidal fracture, low biref. 1.630-1.635 (-) . . . . Tourmaline

Blades ca 1.63-1.65 (-) . . . .

Biaxial . . . . Barite

somewhat tabular 1.636-1.647; 2V = 37° (+). . . . . Forsterite (Olivine)

conchoidal fracture 1.64-1.67 . . . . Tremolite

excellent cleavage, obl. extc. 1.61-1.63, 2V ca 75° . . . . Enstatite

like tremolite but orthorhombic 2V ca 60°. (+) r>b . . . .

Indices sl. > 1.55

Uniaxial . . . . Quartz

Conchoidal fracture, low biref. (+) 1.554-1.553 . . . . Beryl

Conchoidal fracture, low biref. (-) 1.57-1.58 . . . .

Biaxial . . . . Muscovite

Micaceous, 2V = 30-47° (-) r>b. . . . . Anorthite

Tabular, twinned 2V = 78° (-) r>b, 1.577-1.590. . . . .

INDICES < 1.544 (Canada balsam)

Twinning . . . . Microcline

Crossed lamellar twinning, 2V = 66-103° (-) 1.52-1.53. . . . . Gypsum

Possible "arrowhead" twins, monocl. rhombs, heat → anhyd. pseudomorphs. . . . . (high temperature) Albite

Albite twinning, 2V = 45° (-) r>b, 1.527-1.534 . . . . (low temperature) Albite

Albite twinning, 2V = 77° (+), r>b, 1.527-1.538. . . . . Orthoclase

No multiple twinning, 2V = 33-103° (-), 1.52-1.53 . . . .

wcm 1-1-79

1. Light Microscopy

The starting point is to consider a basic set of classification properties based on observations readily made microscopically. Some of these relatively simple observations are used to classify particles into a small number of subgroups. A second set of properties requiring more time and effort are used to identify individual substances within each subgroup. The basic classification characteristics chosen are:

- transparency
- color (transmitted light)
- color (reflected light)
- birefringence
- refractive index (relative to Aroclor® 5442)
- shape

Supplementary properties useful for identification of individual substances within a subgroup are given in Figure 333 in the preceding section. Obviously, if we measure both the basic and supplementary characteristics on a single particle, it will be uniquely characterized. That is, no other particle should give the same set of characteristics unless the two are identical. Fortunately, it is not necessary to measure all of these properties in order to identify a given particle. A relatively small group of basic properties, optical and morphological observations, usually suffices.

Before classifying particles in any system, we must start by defining a particle as the largest possible *homogeneous* unit. In agglomerates, the individual particle, rather than the agglomerate itself, is described. This is especially important when the individual particles are very small, isotropic and highly refractive since the agglomerate may appear opaque (due to light scattering) even though the individual particles are transparent.

The system chosen uses either 0 to 1 to signify the presence or absence of six different characteristics of the particles. The rules follow.

First digit: Transparency. The digit "1" means the particle is opaque, that is, 100% absorbing throughout the visible light range. The digit "0" means the particle is transparent, whether colored or colorless.

Second digit: Color. The digit "1" means the particle shows some color (by transmission if first digit is "0," by reflection if first digit is "1." A second digit of "0" means the particle is colorless (white if transparent, black if opaque). A complication here is what to do for substances showing a color due to impurity atoms (silica sand containing iron), nonstoichiometry (like silicon carbide, titanium dioxide etc.) or structural colors (like some diatoms). These should be classified as colored: however, the detailed description of the known substance should indicate these possibilities. When any colored particle is observed, one should consider the possibility that it may be a colorless substance in its pure state. Substances that may be either colored or colorless (like power plant flyash) should be classified both as -1---- and -0----. Even though a substance is colored, a 5 μm thick particle might appear colorless, then the classification should include both possibilities: -0---- and -1----. Neutral gray particles, incidentally, are classified 010000.

Third digit: Anisotropy. A "1" means anisotropic, a "0" isotropic *or apparently so*. Obviously, small particles of many low birefringent substances will have insufficient retardation to show visible polarization colors. Even substances of high birefringence may be oriented so that the retardation is low, or they may lie in an extinction position. Rotation of the stage with a first order red compensator in place is helpful in detecting low retardation. Occasionally, however, an anisotropic particle has such extremely low retardation that it is essentially undetectable even with the compensator. Rotation of the stage with a single polar may show contrast changes and even Becke line variations; these indicate anisotropy and justify a "1." If no anisotropy or contrast variation on rotation is apparent, there is nothing to do but to assign "0" as the third digit for that particle. Strain birefringence is also classified as anisotropic.

Fourth digit: Refractive index. A "1" means that at least one refractive index of the substance is greater than n^D_{25} = 1.660 (Aroclor® 5442). A "0" means that all apparent refractive indices are less than or equal to n^{25}_D = 1.660.

Fifth digit: Shape. A "1" means that only one dimension is one-fourth (or less) of the other two. A "0" means that the particle is elongated or equant.

Sixth digit: Shape. A "1" means that only one dimension is four times (or more) the other two (needles or rods). A "0" means flat or equant.

Taken together, digits 5 and 6 describe the particle shape:

----11 means elongated and flattened, *i.e.*, a ribbon, blade, lath etc.
----10 means flattened but not elongated, *i.e.*, a plate or tablet
----01 means elongated but not flattened, *i.e.*, a needle or rod
----00 means neither elongated nor flattened, *i.e.*, an equant particle

Now, since opaque particles 1----- cannot show polarization colors or refractive indices by transmitted light, all opaque particles will be 1-00--. There are, therefore, only 8 categories for opaque particles, 4 colored and 4 colorless, of which 3 are not yet represented by known particles: 110001, 110010 and 110011. There are, however, 32 categories for transparent particles, and, of these, 7 are not yet represented by known particles: 000101, 000110, 000111, 010101, 010110, 010111 and 011111. This is because isotropic substances do not generally show elongation or flatness; hence, particles classified as --0--- are usually also --0-00. Some of these other categories (--0-11, --0-10 and --0-01) are represented, however, because the method of formation can cause isotropic substances to be elongated (salt, whiskers, fiber glass etc.) or flattened (pumice, perlite, seismotite etc.). Figure 334 summarizes the meaning of the six-digit code.

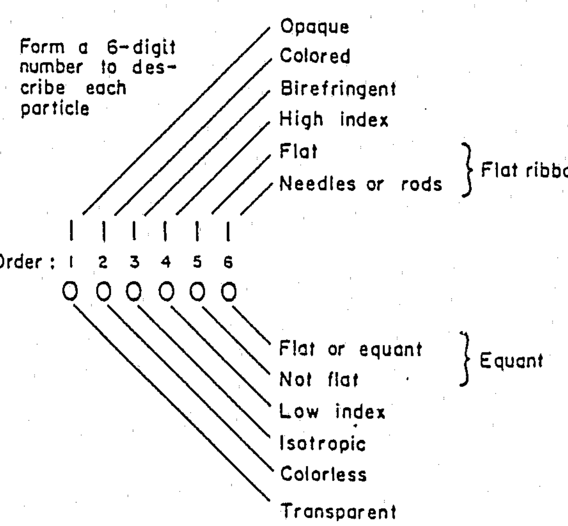


Figure 334. The meaning of the six-digit code as used for particle description.

The six-digit code can also be adapted very nicely to a binary code based on values of 32, 16, 8, 4, 2 and 1, in that order, for the six digits. The binary code is common computer language whereas the six-digit code is, at best, awkward computer language. In any case, either is easily converted to its equivalent.

Each of the six positions of the six-digit code is assigned a numerical value as follows.

1	1	1	1	1	1
32	16	8	4	2	1

The binary code for a given classification is then the numerical sum of the values for those positions of the six-digit code filled by the figure 1. The following examples illustrate the equivalence between the binary and six-digit codes.

100000 = 32	100010 = 34
010000 = 16	110011 = 51
000100 = 4	100001 = 33
000001 = 1	001100 = 12

The use of such a system reduces the number of possible substances so that inspection of a set of photomicrographs of known substances in that category alone may complete the identification.

In many cases, particularly transparent, colorless, anisotropic, low refractive index, equant particles (8:001000), additional measurements are required. There are also many fibers in 9:001001, and these must be further differentiated by appropriate observations. The kinds of observations best suited to identifying individual substances within a given category will vary. For example, x-ray data are not very useful for fibers, nor is dispersion staining or optical crystallography very helpful for opaque substances.

One solution to this problem is to list all of the properties of each substance in a description accompanying each photograph (see Volume II, *Particle Atlas Two*). A second solution is to tabulate the most generally useful of these properties for all substances in a given category. For example, the refractive indices parallel to and normal to the length of all fibers are tabulated in order of increasing index. Tables of this type will be found in Volume IV, *Particle Atlas Two*.

FIBER IDENTIFICATION

- ISOTROPIC
  - Fiberglass - uniform diameter straight colorless
  - Mineral wool - exotic shapes, irregular diameters - may be brown or gray
  - Arnel - not truly isotropic but often $n_{\parallel}-n_{\perp}$ <0.001
- ANISOTROPIC
  - Low Birefringence
    - Arnel (+)
    - Dynel (+); n's ca 1.534
    - Cellulose Acetate (+) n's ca 1.474
    - Orlon (-) n's ca 1.513
  - Moderate Birefringence
    - Viscose Rayon (+); n-s 1.53 & 1.55
    - Cotton-twists; (+); no extinction; n's 1.53 & 1.58
    - Wool & other animals-oral; (+) scales; (=) n's 1.5 & 1.6
    - Silk - crossover marks; (+) n's = 1.54 & 1.59
    - Linen & other bast fibers - (+); nodes; n's = 1.53 & 1.59
    - Straw - lignified, serrated cells short baggy cells
    - Coniferous wood - flat fibers with pits
    - Nonconiferous wood - flat fibers without pits; baggy cells with multiple rows of pits
    - (Coniferous and nonconiferous wood:) Chemical pulp whole individual fibers; Mechanical pulp torn groups of fibers
    - Asbestos - v. fine fibrils - inorganic
  - High Birefringence
    - Nylon n's <1.66
    - Dacron $n_{\parallel}$ = 1.72, $n_{\perp}$ = 1.53
    - Nomax $n_{\parallel}$ = 1.70, $n_{\perp}$ = 1.67
    - Kevlar $n_{\parallel}$ >2.30

SAFE INSULATION

Definition: Any material inbetween the walls of safes or safe cabinets that helps prevent the contents from burning.

There are 5 general types in most safes encountered:

1. Vermiculite type - vermiculite, diatoms and Portland cement.
2. Natural cement.
3. Gypsum and sawdust or wood chips.
4. Gypsum.
5. Frothy cement and vermiculite.

Many modern safes use the first type which is specifically approved by fire underwriters. The diatoms are usually seen as fragments and the vermiculite gives a biotite x-ray pattern because of calcining. If all three of the materials are present, it can be stated that the material, even in very small particles, came from a safe and no other source. The following use this type:

- Mosler Safe Company
- Diebold Safe Company
- Meilink Steel Safe Company (use fresh water diatoms and can be named as a brand exclusive of all others)
- R. C. Allen Safe Company
- Herring-Hall-Marvin (owned by Diebold), (made some Tower, Sears brand safes)
- Schwabb Safe Company (as of 1977, see below for older Schwabb)
- Protectall (owned by Mosler)
- York, modern (made by Diebold)
- Some Art Metal
- Some General Fireproofing

The above type is identified by observation, low power incident microscopical study and observation of the diatoms at about 360 power by transmitted light after removal of the cement with HCl. Diebold and Mosler are nearly alike. Small particles of Mosler may have only spicules visible (isotropic rods). Meilink diatoms are specific to that safe. R. C. Allen has many more diatom fragments.

Natural cement was used by many companies in safes made before 1920. This was made by calcining argillaceous limestone without clinkering or by burning layers of coal and limestone in a tower. Shaley particles and/or cinders can be seen; the particles may be black or of many colors. Makes cannot be named, but natural cement is good for comparison purposes. The inclusions and composition of the cement are quite variable among safes. It was only used in the neat form in safes and, therefore, can be stated to be safe insulation from an older safe and no other source has been known.

Distributed by Elmer T. Miller at the NEAFS meeting October 29, 1977.

Gypsum and sawdust was used in safes made by Remington Rand, Tonawanda, New York. There are six brands, but only "Victor" has pink gypsum. Unless pink, this material cannot be stated to be safe insulation to the exclusion of all other sources. This type was discontinued in 1976 and Sperry Univac Corporation (now owns Remington Rand) uses frothy gypsum with no filler.

Gypsum cannot be stated to be safe insulation. It is used in plasterboard, but there it has fillers such as dolomite, paper fibers or glass fibers. Gypsum has been used in:

- Shaw Walker
- Victor
- Mosler (safe cabinets only)
- Marvin
- Sperry Univac which owns:
  - Remington Rand
  - Sperry Remington
  - Victory Office Equipment
  - Safe Cabinet Company
  - General Fireproofing
  - Surety Safe and Vault

Frothy cement and vermiculite is made by mixing Portland cement and vermiculite with a frothing agent and beating. It was first used by Diebold in their light-weight safes and in safe cabinets. A similar product is used in modern roof supports in fireproof buildings. It, therefore, cannot be stated to be safe insulation to the exclusion of all other sources, but it is distinctive and good for comparisons. It is used in:

- Diebold light weight safes and safe cabinets
- Star
- LeFebure (doors only)
- J. D. Brush (since 1971 in Sentry and Keep/Safe brands)

There are many, some obsolete, which are quite distinctive and not only the fact that they are safe insulation, but even the make of safe can be determined. Some, like Meilink and R. C. Allen, have a common type but the peculiarity must be known. These are recognition situations:

Art Metal (most)
1. Gypsum and cork
2. Gypsum, asbestos, $CaCO_3$, trace diatoms

Atlas Safe Company
1. Crushed dolomite and natural cement

Barnes Safe Company
1. Natural cement, cinders, furnace slag

J. D. Brush Company
1. Vermiculite, $CaCO_3$, sand, biotite, $Ca(OH)_2$ (prior 1971)
2. Cement and glass fibers (Survivor brand) (Modern)
3. Foamed cment and vermiculite (since 1971, Sentry and Keep/Safe)

Brush-Punnet Company
1. As above for J. D. Brush
2. Natural cement
3. Portland cement, ashes, cinders, coal (older Sentry brand)

York Safe and Lock (Older)
Discrete lumps of clay and diatomaceous earth bonded together with Portland cement. Very distinctive, can be "called" even if found in the separate lumps and in separate particles on the same item. (As above, modern York safes have Diebold insulation.)

General Fireproofing
Gypsum, diatoms and asbestos

Schwabb (also makes Berger, Carey, Van Dorne safes)
1. Natural cement
2. Asbestos and glass wool in $CaCO_3$
3. Portland cement and diatoms
4. Frothy cement
5. Diatoms and argillaceous limestone

Protectall
1. Cement, diatoms, slag, vermiculite
2. Cement and vermiculite

Shaw-Walker
1. Gypsum (now makes safe cabinets only)

Valentine Safe and Lock Company
Vermiculite, cement and sand

Yawman and Erbe (obsolete, made about 1920-1924)
Gypsum, diatoms, blue asbestos

Concrete, kaolin, slag, asbestos etc. have been used in a few safes, mostly obsolute and not nameable.

Some insulations are painted on the surface, some safes are painted on the inside surfaces of the walls to prevent corrosion.

Many safes have the locking mechanism set in gypsum although this is not the insulation in the remainder of the safe.

Many safes have been repaired or rebuilt and have gypsum, plaster or concrete in portions only.

Very hard white lead putty or red lead putty is typically present on or to fill flaws in metal of older safes.

Some York safes have alum in trays or pans imbedded in the doors. Some Remington-Rand safes have sodium bicarbonate in pans in the doors. Some other safes have alum or epsom salts in the doors and many have tear gas vials imbedded in or inside the doors. The glass is good evidence.

FIBER IDENTIFICATION

ISOTROPIC
- *Fiberglass - uniform diameter straight colorless*
- *Mineral wool - exotic shapes, irregular diameters - may be brown or gray*
- *Arnel - not truly isotropic but often* $n_{\parallel}-n_{\perp} < 0.001$

ANISOTROPIC

Low Birefringence
- *Arnel (+)*
- *Dynel (+); n's ca 1.534*
- *Cellulose Acetate (+) n's ca 1.474*
- *Orlon (-) n's ca 1.513*

Moderate Birefringence
- *Viscose Rayon (+); n-s 1.53 & 1.55*
- *Cotton-twists; (+); no extinction; n's 1.53 & 1.58*
- *Wool & other animals-oral; (+) scales; (=) n's 1.5 & 1.6*
- *Silk - crossover marks; (+) n's = 1.54 & 1.59*
- *Linen & other bast fibers - (+); nodes; n's = 1.53 & 1.59*
- *Straw - lignified, serrated cells short baggy cells*
- *Coniferous wood - flat fibers with pits*
- *Nonconiferous wood - flat fibers without pits; baggy cells with multiple rows of pits*
- *Asbestos - v. fine fibrils - inorganic*

Chemical pulp whole individual fibers / *Mechanical pulp torn groups of fibers* (bracketed to Coniferous wood and Nonconiferous wood)

High Birefringence
- *Nylon n's <1.66*
- *Dacron* $n_{\parallel} = 1.72$, $n_{\perp} = 1.53$
- *Nomax* $n_{\parallel} = 1.70$, $n_{\perp} = 1.67$
- *Kevril*
- *Kevlar*

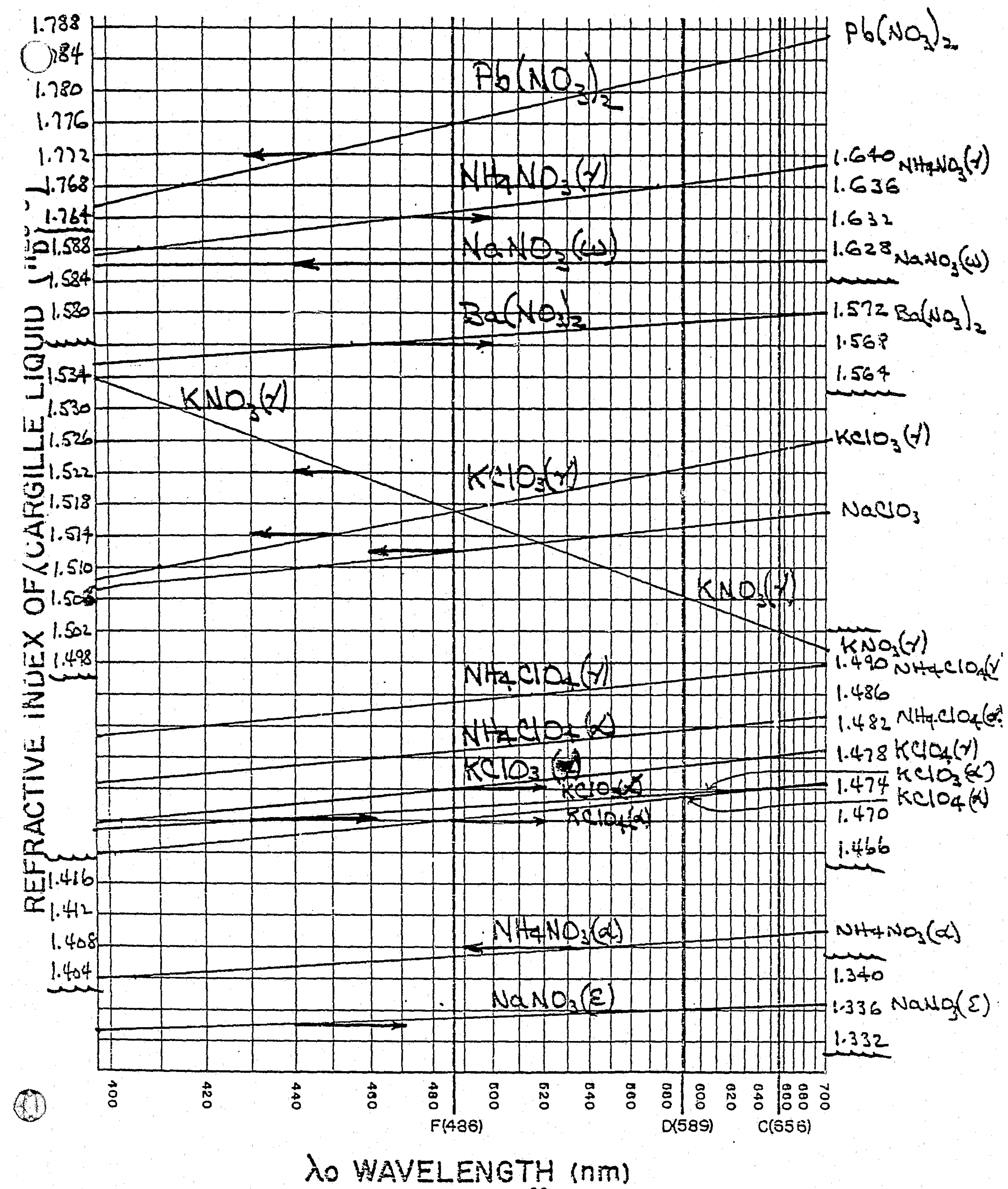
APPENDIX D

MINIMUM SPECIFICATIONS FOR A POLARIZING MICROSCOPE

1. *Monocular upright bodytube*
2. *Rotating stage (or simultaneously rotating polars)*
3. *Either stage or objectives must be centerable (but not both)*
4. *Focusable >0.9 NA condenser capable of Köhler illumination for all objectives*
5. *Three parfocal achromatic objectives, one in each of the ranges: 3.5-6.3X, 8-12X and 40-50X.*
6. *>10X ocular, focusable eyelens with crossline graticule*
7. *>8X ocular, focusable eyelens with micrometer graticule (the crossline and the micrometer scale may be combined in a single graticule in a single >10 ocular)*
8. *Bertrand lens*
9. *Mirror*
10. *Red I compensator and compensator slot*

DESIRABLE ADDITIONAL FEATURES

1. *Inclined bodytube*
2. *Binocular bodytube*
3. *Trinocular bodytube*
4. *Ball-bearing rotating stage*
5. *Spring-mounted objective front lens*
6. *0.85 NA 40-60X objective*
7. *100X oil immersion objective*
8. *Better corrected objectives: fluorites, apochromats or planapochromats*
9. *15-20X ocular*
10. *Built-in Köhler illumination*
11. *Centerable substage condenser*
12. *Quarter-wave plate*
13. *3-4 order variable retardation compensator*
14. *Interference filters for F, D and C lines*
15. *Rotating nosepiece*
16. *Centerable focusable Bertrand*
17. *Neutral density filters (0.1, 0.3, 0.7)*
18. *High-eyepoint oculars*
19. *Wide-field oculars*



MINIMUM SPECIFICATIONS FOR A TUNGSTEN FILAMENT MICROSCOPE ILLUMINATOR

It must be possible to achieve good Köhler illumination with all objectives and any ≥0.9 NA condenser. This requires the ability to 1) focus a clear image of the lamp filament in the plane of the substage aperture diaphram as determined by observing its conjugate focus, the objective back focal plane, with the Bertrand lens; and 2) focus a clear image of the field diaphram (lamp iris) centered in the plane of the preparation. To do this will require:

1. *clear bulb*
2. *compact filament, ideally a square array 2-3 mm on edge with closely spaced filament wires*
3. *centerable bulb*
4. *lamp condenser lens diameter of ≥40 mm*
5. *lamp iris covering full lamp condenser lens opening*
6. *lamp condenser to filament distance continuously variable to permit focusing a sharp image of the filament 10-40 cm in front of lamp*
7. *field diaphram should not change its position when the filament focus is changed*
8. *lamp capable of x, y and z movement*
9. *diffuser, if present, removable*
10. *clear daylight blue filter*
11. *filter holder*

MINIMUM SPECIFICATIONS FOR STEREOBINOCULAR MICROSCOPES

Two identical independent optical paths, one for each eye.
Interocular distance continuously variable from 55-70 mm.
One independently focusable ocular.
One ocular with micrometer scale (focusable top lens on ocular).
Total magnification range 5-100X with at least 4 magnification steps.
Numerical aperture at highest magnification ≥0.13

DESIRABLE ADDITIONAL FEATURES

Transmitted light capability.
Zoom optics.
Trinocular bodytube.
Higher top magnification, e.g., 200X.
Concave front surface objective lens acting as a Lieberkuhn illuminator (brightfield top light by reflection of transmitted light back onto specimen; see PA II, Vol. I, pp 239).
Large stand to permit viewing large samples.
Easily offset optics for straight-through photomicrography.
Polars with rotating stage.
Aperture diaphram in the bodytube.

APPENDIX E

NAME ____________________

QUIZ DUE TUESDAY MORNING

1. A man 1.8 m tall standing 2.0 m from a vertical plane mirror just barely sees his full length. How long is the mirror and what is its position?

2. As you look through the microscope, what planes are in good focus on the retina under the following conditions?

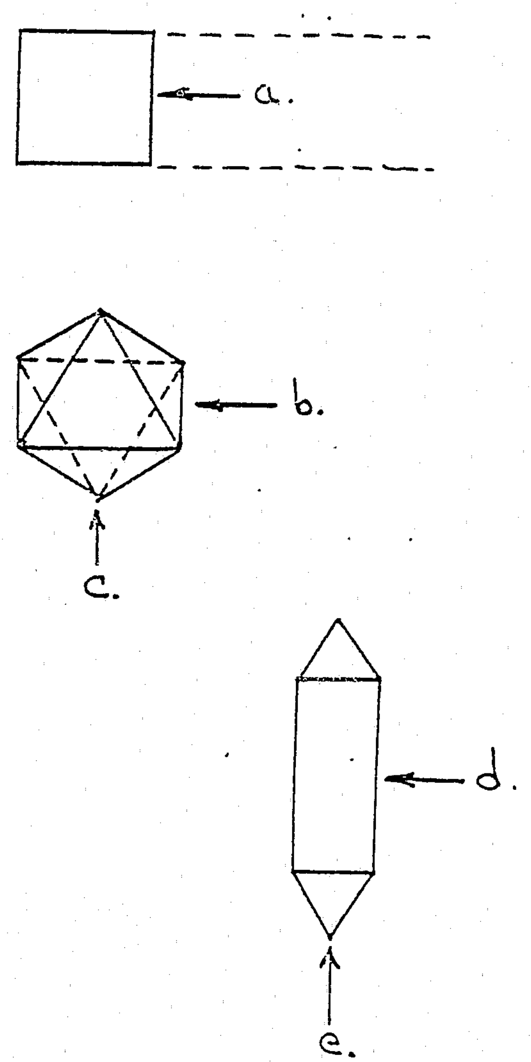
	filament	field diaphram	aperture diaphram	preparation	objective back focal plane	ocular front focal plane
Köhler						
Orthoscopically						
Conoscopically*						
Critical (Nelsonian)						
Orthoscopically*						
Conoscopically						
Diffuse						
Orthoscopically						
Conoscopically*						

*Bertrand lens in

3/79

QUIZ DUE WEDNESDAY MORNING

1. *Draw all possible indicated views of these three crystals. Assume each crystal is lying on a flat face with all arrows in that same plane. You are looking perpendicular to the flat face and arrows.*



OVER.

2. *Explain why oriented polymer fibers behave optically like uniaxial crystals, i.e., ω corresponds to* $n_\perp$ *and* ε *to* $n_\parallel$.

3. *Explain why oriented polymers films behave optically like orthorhombic crystals, i.e., α, β and γ corresponding to three principal indices of the film.*

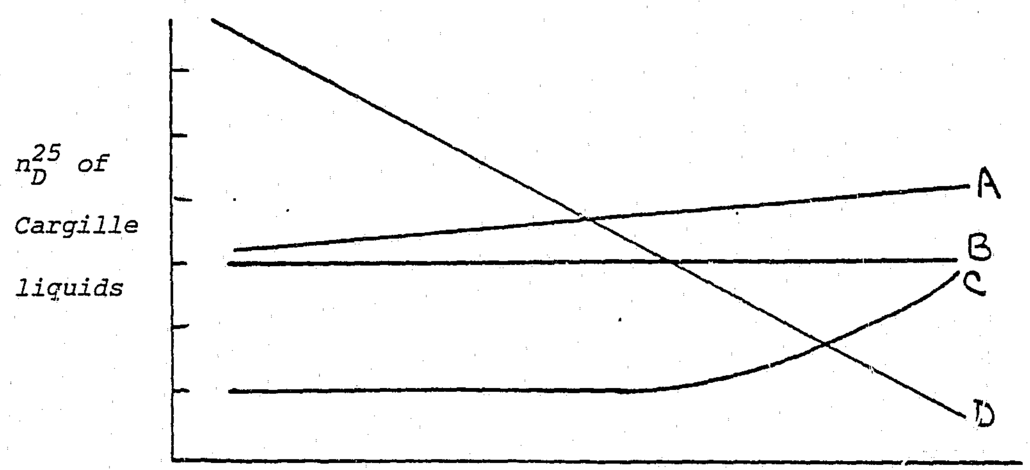
NAME ______________________

QUIZ DUE THURSDAY MORNING

1. A cylindrical fiber 20 μm in diameter shows a third-order blue-green between crossed polars. What could it be?

2. A crystal about 11 μm thick lying on a flat face shows an optic normal interference figure and a very slightly yellow first-order polarization color, estimated ≅300 nm. The crystal came from a cake mix, what is it?

3. What can you say about the dispersion of refractive index (relative to the Cargille liquids) for the compounds whose dispersion staining curves are shown below (see Course Manual pages 178-180) —



NAME ______________________

QUIZ DUE FRIDAY MORNING

1. What characteristics do you associate with particles classified as:

33:100001 ______________________

22:010110 ______________________

3:000011 ______________________

2. How would you most expeditiously differentiate:

Quartz from ground glass? ______________________

Corn starch from wheat starch? ______________________

Coniferous from nonconiferous wood fibers? ______________________

Orlon from cellulose acetate? ______________________

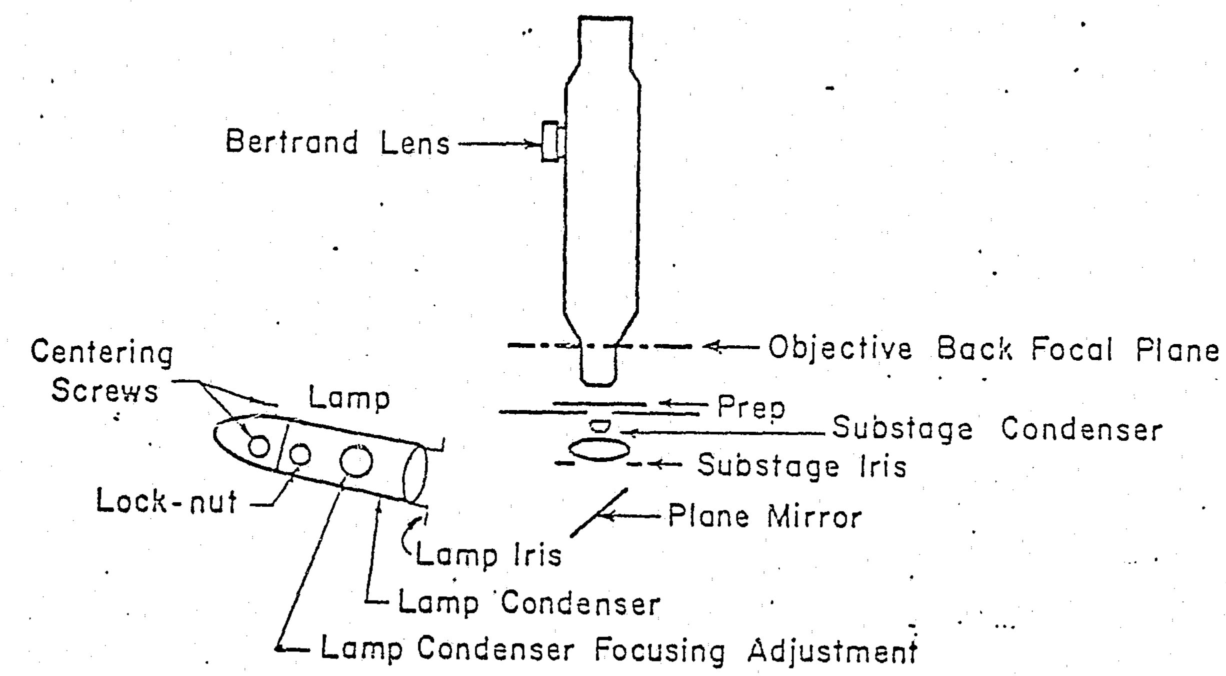
Mill scale from graphite? ______________________

APPENDIX F

QUICK CHECK OF KÖHLER ILLUMINATION

1. FOCUS ON PREP.
2. CLOSE LAMP IRIS (FIELD DIAPHRAM).
3. FOCUS FIELD DIAPHRAM BY SLIDING CONDENSER ↑↓.
4. CENTER FIELD DIAPHRAM WITH MIRROR.
5. INSERT BERTRAND.
6. OPEN SUBSTAGE IRIS (APERTURE DIAPHRAM).
7. FOCUS FILAMENT WITH LAMP ADJUSTING KNOB.
8. CENTER FILAMENT BY MOVING LAMP.
9. REMOVE BERTRAND.
10. ADJUST CONTRAST FOR THAT SPECIMEN WITH APERTURE DIAPHRAM.

Monday a. m. - Köhler Illumination

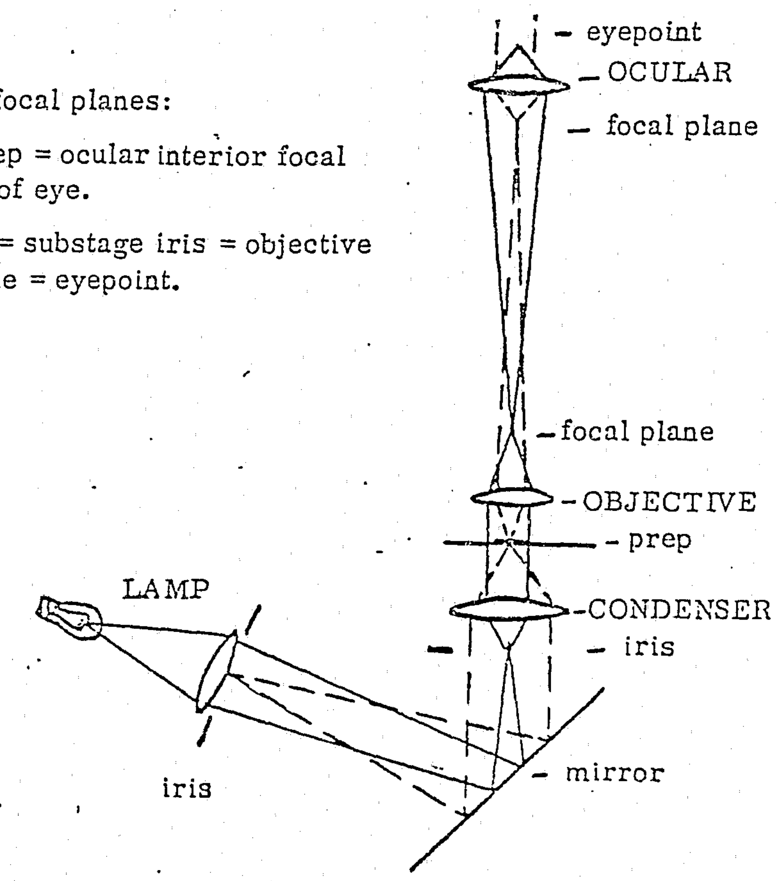


Olympus Microscope and Illuminator

Note conjugal focal planes:

→lamp iris = prep = ocular interior focal plane = retina of eye.

→lamp filament = substage iris = objective back focal plane = eyepoint.



KÖHLER ILLUMINATION

Steps to obtain Köhler illumination:

1. Focus lamp filament on a surface ≤ 6" from front of lamp.
2. Rotate bulb in its fixture and center filament if the filament image does not stay centered on rotation.
3. Place lamp in front of microscope with its front lens 4-6" from mirror; aim lamp at middle of plane mirror.
4. Using the 16-mm (10X) objective and any prep on the microscope stage, tilt the mirror to illuminate the field of view and focus the microscope on the prep. (Don't worry if the illumination is bad.)
5. The sliding auxiliary lens in the bottom of the substage should be out of the light path (slide to the right).
6. Insert the Bertrand lens, open the substage iris, then focus the lamp filament in the objective back focal plane using the lamp condenser.
7. Move the lamp closer to the microscope, if necessary, to fully (not necessarily evenly) illuminate the objective back focal plane.
8. Remove the Bertrand, close the lamp iris (field diaphram) and center its image in the field of view (be sure the prep is in focus) by tilting the mirror.
9. Focus the lamp iris in the field of view by sliding the substage condenser up and down. There is a set screw at the front of the condenser.
10. Open the centered lamp iris just to the edge of the field of view.
11. Recheck (step 7) the objective back focal plane by inserting the Bertrand. Focus the filament if necessary by moving the lamp condenser. If the back focal plane is not completely illuminated, move the filament image by swinging or tilting the lamp. Be careful to leave the lamp iris in the same position so that the lamp iris image in the field of view remains centered (or recenter).
12. Adjust the substage iris to give the optimum compromise between contrast and resolving power. At least 70% of the objective back focal plane should be fully illuminated with the optimum setting of the substage iris.

Every microscope can be adjusted in ways analogous to the above directions and they must be checked regularly by every microscopist. Every experienced microscopist can tell at a glance if the microscope illumination is properly adjusted.

KÖHLER ILLUMINATION (ANY MICROSCOPE)

1. CENTER LAMP FILAMENT ON AXIS OF LAMP CONDENSER (USE LAMP CENTERING SCREWS).
2. FOCUS LAMP FILAMENT ON CENTER OF MICROSCOPE MIRROR AND 10 cm DISTANT.
3. TILT MIRROR TO THROW SOME LIGHT INTO MICROSCOPE.
4. FOCUS ON ANY PREPARATION.
5. FOCUS OCULAR CROSSLINES (ROTATE OCULAR TOP LENS).
6. CENTER STAGE ROTATION.
7. CLOSE FIELD DIAPHRAM (F.D.) (ON LAMP); TILT MIRROR IF NECESSARY TO KEEP IMAGE OF F.D. IN FIELD OF VIEW.
8. FOCUS IMAGE OF F.D. (SUBSTAGE CONDENSER UP OR DOWN).
9. CENTER F.D. (TILT MIRROR OR CENTER SUBSTAGE CONDENSER.*

INSERT BERTRAND LENS —

10. FOCUS IMAGE OF FILAMENT IN OBJECTIVE BACK FOCAL PLANE (ADJUSTMENT ON LAMP).
11. CENTER IMAGE OF FILAMENT (MOVING LAMP).
12. RECHECK 9.
13. ADJUST SUBSTAGE APERTURE DIAPHRAM FOR OPTIMUM CONTRAST.

* FIRST OBJECTIVE, CENTER ADDITIONAL OBJECTIVES AT NOSEPIECE.

NAME ____________________

APPENDIX G

FINAL EXAM

1. *The magnification of an objective having a maximum NA of 0.25 should be about _____X.*

2. *A given crystal has principal refractive index values of 1.522, 1.552 and 1.606. The crystal is uniaxial: true ____? false ____?; monoclinic: true ____? false ____? could be ____?; optically positive: true ____? false ____?*

3. *A 1 μm spherical particle will weigh about 10^{-} g?*

4. *Bright dispersion staining colors mean the refractive indices of particle and mountant are very close together: true ____? false ____?*

5. *Every crystal of a uniaxial substance no matter what its orientation always shows the same common refractive index sometime during rotation of the stage: true ____? false ____?*

6. *Refractive indices increase with increasing density (true ____? false ____?) and decrease with increasing atomic number (true ____? false ____?).*

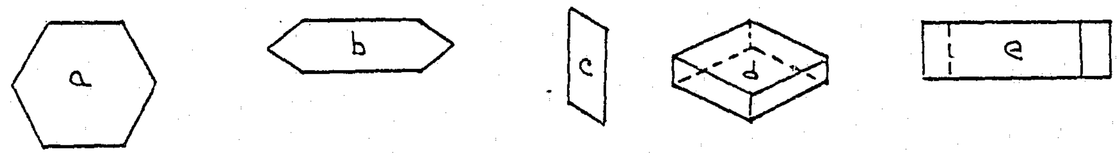
7. *What steps could you take to set up Köhler illumination if your microscope has no Bertrand lens?*

8. *The light intensity is too high for comfortable orthoscopic illumination. Which of the following steps would you take to decrease the intensity:*

   a. *close down the substage aperture diaphram?____________________*
   b. *close down the field diaphram?____________________*
   c. *use neutral density filters?____________________*
   d. *decrease the lamp voltage?____________________*
   e. *lower the substage condenser?____________________*

9. *Small particles can be resolved best with: white____, red____, yellow____, green____, blue____ light or it doesn't matter ____?*

10. *What can you say about the crystal system for each of these crystal views?*



11. *What can you suggest to improve this course?*

12. *What features of this course do you feel should be continued in future forensic microscopy courses?*

APPENDIX H

Proficiency Test - Explosives and Fibers

It is now several months since your polarized light microscopy (PLM) course. A final responsibility on your part is a proficiency test based on material you learned as a result of that course. An official course certificate indicating successful completion will be mailed to you only after you report your results. Good luck.

The microscopy workshop you have taken emphasized the determination of identifying characteristics using the polarizing microscope. Once learned, these techniques and observations can be applied to nearly all categories of trace evidence (glass, fibers, hair, soils, drugs, paint and explosives in particular). Because the emphasis is on the characterization and identification of small particles in general, we are using the same evidence categories for each of you. This makes the test fairer for all by avoiding grading "apples versus bananas."

This test is in two parts, both requiring application of polarized light microscopy. First is one of a group of fiber unknowns labeled F-1 through F-27. You should identify it by diameter, crossection (inferred from the longitudinal views), surface markings and optical properties. The attached tabulation of fiber characteristics may be useful.

Explosives are an important part of the caseload of all crime laboratories and lend themselves particularly well to microscopical identification, hence each of you is being asked to identify two samples of explosive. One is organic and the other inorganic (black powder). You should do your best to identify each but, in any case, you should send a summary of the steps taken, observations made and conclusions reached. A photocopy of your notebook pages would be an easy way to satisfy this requirement.

SAMPLE A (Inorganic)

The black particles in Sample A are, of course, carbon and should be ignored. The best approach for a polarized light microscopist in identifying explosive components is to use birefringence and refractive index followed, if necessary, by particle morphology, recrystallization and microchemical tests. Fortunately, there are relatively few inorganic explosives used and these are listed with refractive index data in Figure 1.

Preparation of Sample

If possible, pick out one or more apparently identical crystals (don't worry about a bit of adhering charcoal). If there are groups of crystals having quite different appearance, pick each separately and analyze each separately. If the crystals are too small to pick out a sufficient sample, then mount a small bit of the whole sample in a liquid 1.586 ± 0.004 and check the transparent crystals for anisotropy, birefringence and general shape characteristics. This liquid, along with crossed polars observations, will identify $Ba(NO_3)_2$, NH_4NO_3 and $NaNO_3$. Are there two or more components (besides charcoal)?

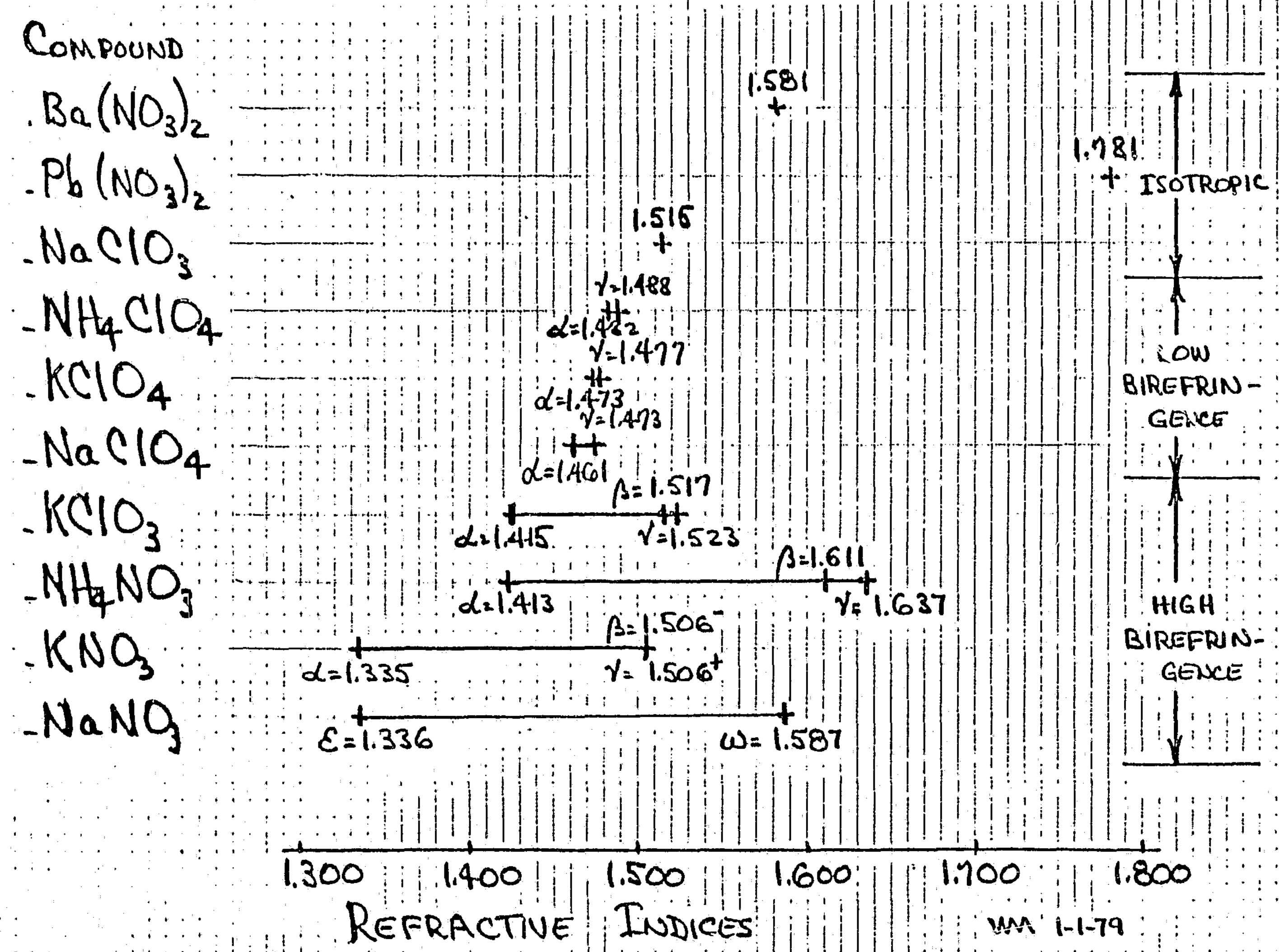
If there is more than one oxidant you won't be able to extract with water or recrystallize from water because of possible reactions in solution to give other reaction products. In any case, use the attached refractive index Figure 1 and the fact that you have the crystals in a specific index liquid to draw all the conclusions you can. Proceed based on results obtained.

Cautions:

1. *Never dissolve, melt etc. the entire sample. Use small aliquots.*
2. *Sulfur or aluminum may also be present. The latter will be apparent as thin flakes: opaque by transmitted light and metallic by reflected light. Sulfur will be transparent, faintly yellow, insoluble in water and with very high refractive indices (1.9579, 2.0377 and 2.2452). It melts, however, at 119°C.*

FIGURE 1

REFRACTIVE INDICES OF INORGANIC EXPLOSIVES



You may decide to mount a second small portion of the sample in a second or even a third liquid of known refraction index before continuing with other tests.

Recrystallization from Water

All of the oxidant compounds in Sample A are water-soluble and recrystallize from a drop of water on a slide. Be sure you stir and crush plenty of crystals into a deep drop. There should always be at least a slight excess of undissolved crystals in the center of the drop. You should continue to crush and stir (and push the edge-crust into the drop) until individual well-formed crystals begin to appear. Then note and carefully draw representative crystals before they go dry (90° angles should be 90°; 60° angles should be 60° etc.). You should also check the degree of birefringence (low, medium or high): when all colors, regardless of thickness and orientation, are gray or white the crystals have low retardation and low birefringence; brilliant colors (1-3rd order) on crystals as large as 5-15% of field diameter means moderate birefringence; white on the larger crystals and colors on tapered edges or thin crystals signifies high birefringence. You should also check extinction (parallel, symmetrical or oblique) between crossed polars. Identical crystals from a water drop (shape, interfacial angles, birefringence, extinction etc. are good evidence for identity.

Microchemical Tests

Even when you think you know what you have, a microchemical test will be good for confirmation. Some useful tests include:

lead — 1) Mix 2 drops, one very dilute potassium iodide and the other very dilute unknown crystals. If lead is present, lead iodide will precipitate as thin yellow hexagonal plates; or 2) Add a small particle of metallic zinc or magnesium to a dilute test drop. Metallic lead dendrites will grow in the drop if lead is present.

potassium — Add a small crystal of ammonium perchlorate to a concentrated test drop. An immediate precipitate of low birefringent orthorhombic "bipyramids" (actually 2 sets of prisms) prove potassium was present.

ammonium — If potassium is absent, a dilute drop of chloroplatinic acid will precipitate cubic (isotropic) orange octahedra from a test drop containing ammonium ions. If potassium was present, the same test can be used but the reagent must be placed in a hanging drop above a warmed (50-70°C) alkaline test drop. A simple and convenient closed cell is formed with a coverslip over a plastic vial cap.

sodium — If potassium and ammonium are absent and sodium is present, a chloroplatinic acid drop drawn across a dried test drop residue will yield triclinic blades of sodium chloroplatinate with oblique extinction (22°). If either potassium or ammonium are present a concentrated drop of uranyl acetate in dilute acetic acid drawn across a dried drop residue containing sodium will precipitate black (due to total reflection) tetrahedra with triangular outlines.

barium — If lead is absent, mixing a dilute drop of sodium or potassium chromate with a dilute test drop will yield a yellow precipitate of barium chromate. If lead is present, add a dilute chromate drop to the test drop after the magnesium metal has had a chance to precipitate all of the lead. (Use plenty of magnesium or zinc powder and if drop goes dry add water before adding the chromate drop.)

Fusion Methods

All of the inorganic explosives melt above the Mettler 300°C range (Table I) except ammonium nitrate (m.p. 169.6°C). Sulfur, incidentally, will melt at 119°C. Although this means a hotstage is not the way to go, one can melt a few crystals (more the better) and note the crystal habit and optics on crystallization. Better still, when you think you have identified, say, sodium nitrate ($NaNO_3$), a known sample of $NaNO_3$ can be melted between slide and coverslip and allowed to cool before adding a sample of the unknown (minus the charcoal) at the edge of the coverslip and reheating to melt the added unknown and part of the known $NaNO_3$. Watching the $NaNO_3$ crystallize on cooling (with a hand magnifier) up to and through the zone of mixing will tell whether the unknown is $NaNO_3$. Further inspection of the cooled preparation microscopically will confirm the conclusion reached. If different compounds, the zone of mixing will show some discontinuity in crystal form or retardation due to a eutectic or etc. No change in crystal growth rate or appearance through the zone of mixing confirms the identity of the two samples.

Table I. Melting points of inorganic explosives and sulfur

Compound	Melting point (°C)
Sulfur, S	119
Ammonium nitrate, NH_4NO_3	169
Sodium chlorate, $NaClO_3$	248
Sodium nitrate, $NaNO_3$	308
Potassium nitrate, KNO_3	333
Potassium chlorate, $KClO_3$	368
Potassium perchlorate, $KClO_4$	400 (with decomposition)
Lead nitrate, $Pb(NO_3)_2$	470 (" ")
Sodium perchlorate, $NaClO_4$	482 (" ")
Barium nitrate, $Ba(NO_3)_2$	592
Ammonium perchlorate, NH_4ClO_4	Decomposes

This test can be performed with any nondecomposing explosive; do

not try it with any perchlorates or lead nitrate. There is no danger — it's simply fruitless except to be able to say "Ah yes, it does decompose."

SAMPLE B (Organic)

There are two general types of organic explosives: nitroaromatics like TNT, tetryl, picric acid (PA) and trinitrobenzene (TNB) and nitramines or nitrates like PETN, RDX and HMX. The latter are generally white and the nitroaromatics are generally yellow or brown. The sample you have is one of these (high) explosives. These compounds are identified most readily by microscopical fusion methods. Table II shows their salient characteristics. Melting points are more useful for the nitroaromatics since no decomposition occurs (unless they are overheated or held too long at the melting point). To obtain hotstage melting points of RDX, HMX or PETN, the sample should be placed in the hotstage at 120°C (20°C below the expected PETN melting point) and heated at a 10°C/min rate. If melting does not occur by 145°C, remove the preparation and continue to heat the hotstage at a 10°C/min rate. Replace the prep at about 180°C and observe up to 205°C. (A solid-solid transformation during this step indicates HMX.) If the transformation occurs or if melting doesn't occur before 205°C, remove the prep and continue to heat the stage. Reintroduce the prep at about 260°C. Sublimation to form hexagonal crystals and melting before 280°C indicate HMX.

Table II. Thermal microscopical characteristics of organic explosives

Nitroaromatic Group (no decomposition on melting, yellow to brown)

Compound	m.p. (°C)	Identifying characteristics
TNT	80.6	broad blades with sawtooth leading edge grow at 60-70°C; readily supercool to room temperature and crystallize rapidly to give "school of fish" crystal habit, parallel extinction, (+) sign of elongation and nearly centered BX_a interference figure on high temperature habit. Thymol mixed fusion yields 68°, 112° and 90°, 90° profile angles; parallel extinction, BX_a figure 2E ca 110°(-); (-) sign of elongation.
TNB	122	superficially like TNT but less supercooling (no school of fish habit). Centered optic normal figure gives parallel extinction and profile angles of 57.5 and 122.5° or 122.5, 115° and 122.5°. Other optic axis views show high 2V; (-) sign of elongation
PA	121.8	also like TNT but less supercooling; pleochroic, anomalous first-order red and second-order blue; thymol mixed fusion shows centered bisectrix figure, (+) sign of elongation, 91°, 88°, 91° interfacial angles.
Tetryl	129	grows very slowly at room temperature but nucleates as coarse spherulites at lower temperatures; only slightly soluble in cold thymol, gives low birefringent blades with optic axis interference figure 2V ca 82° (+).
Nitramines and Nitrates (decompose on melting, colorless)		
RDX	204	sublimes readily to give skeletal plates and tablets. A thymol mixed fusion is not very effective but crystals from thymol on cooling are characteristic (a city map pattern) and individual plates and needles, a rapid solid-solid and slow solution phase transformation may be observed.
HMX	279	sublimes to give uniaxial hexagons with ω = 1.607, thymol mixed fusion impossible because of m.p. difference but HMX recrystallizes from thymol on cooling → a "three-penny nail" habit with a hexagonal plate as "head".
PETN	142	recrystallize from the melt to give long rods, low-order polarization colors changing in a few seconds to even lower first-order gray. Thymol mixed fusion gives well-formed blades with 116.5-127-116.5° profile angles, parallel extinction, (-) sign of elongation.

The optical properties can be used to confirm which of these you have (Table III).

Table III. Optical properties of RDX, HMX and PETN

Compound	Refractive indices			
	α (ω)	β	γ (ε)	
RDX	1.5775	1.5966	1.6015	anomalous colors on optic axis view and on BX_a view, other views normal
HMX	1.589	1.594	1.73	usually well-formed, equant bipyramids and pinacoids
PETN	1.553	—	1.554	uniaxial, very low birefringence, tetragonal prisms and bipyramids of same order

You should be able to tell whether you have one of these seven common high explosives (and which one). If, perchance, you have a compound not in either of these groups, you should characterize it as well as you can by any PLM procedure and tell me what it isn't, if not what it is. Please send me photocopies of your notebook pages covering the steps you took, the results you obtained and the conclusions you drew. Be sure you include your name and the sample designations.

Mail your notebook copies to:

Walter C. McCrone
McCrone Research Institute, Inc.
2508 South Michigan Avenue
Chicago, IL 60616

as soon as possible and not more than two weeks from date of receipt.

If you have any questions on any of this writeup or on the results you obtain, don't hesitate to call me, Lucy McCrone or Skip Palenik (all at 312/842-7100).

Walter C McCrone

Walter C. McCrone

Bibliography

McCrone, W. C., Fusion Methods in Chemical Microscopy, Wiley, NY, 1957. This is "out-of-print" according to Wiley, but I have a few copies available at $10.00 each.

McCrone, W. C., "The identification of high explosives by microscopic(al) fusion methods," Microchemical Journal 3 479-490 (1959).

FIBER IDENTIFICATION

- ISOTROPIC
  - Fiberglass - uniform diameter straight colorless
  - Mineral wool - exotic shapes, irregular diameters - may be brown or gray
  - Arnel - not truly isotropic but often $n_{\parallel}-n_{\perp}$ <0.001
- ANISOTROPIC
  - Low Birefringence
    - Arnel (+)
    - Dynel (+); n's ca 1.534
    - Cellulose Acetate (+) n's ca 1.474
    - Orlon (-) n's ca 1.513
  - Moderate Birefringence
    - Viscose Rayon (+); n-s 1.53 & 1.55
    - Cotton-twists; (+); no extinction; n's 1.53 & 1.58
    - Wool & other animals-oral; (+) scales; (=) n's 1.5 & 1.6
    - Silk - crossover marks; (+) n's = 1.54 & 1.59
    - Linen & other bast fibers - (+); nodes; n's = 1.53 & 1.59
    - Straw - lignified, serrated cells short baggy cells
    - Coniferous wood - flat fibers with pits
    - Nonconiferous wood - flat fibers without pits; baggy cells with multiple rows of pits
    - Asbestos - v. fine fibrils - inorganic
  - High Birefringence
    - Nylon n's <1.66
    - Dacron $n_{\parallel}$ = 1.72, $n_{\perp}$ = 1.53
    - Nomax $n_{\parallel}$ = 1.70, $n_{\perp}$ = 1.67
    - Kevlar $n_{\parallel}$ >2.30

Chemical pulp whole individual fibers

Mechanical pulp torn groups of fibers

APPENDIX I

FORENSIC MICROSCOPY WORKSHOP

EVALUATION FORM

The instructors and project staff seek your assistance in evaluating this forensic microscopy training workshop. Your comments and suggestions will assist in planning future workshops and in evaluating the present training experience. Please take a few moments to complete this evaluation form. DO NOT PUT YOUR NAME ON THIS FORM.

Instructions. For each of the following items choose an answer between ONE (1) and SEVEN (7) that best reflects your opinion on the issue. Use low numbers (1 - 3) to indicate poor or negative responses and high numbers (5 - 7) for good or positive responses. A response of FOUR (4) is neutral.

1. What was the overall value of the microscopy training workshop to you?

   Rating________

2. How closely did the course meet your expectations of what it should be?

   Rating________

3. How well did the course cover the knowledge and skills you feel it should have covered?

   Rating________

4. Has your confidence in yourself as a forensic microscopist changed as a result of this training workshop? (Use 1-3 for negative change and 5-7 for positive change.)

   Rating________

5. Rate your instructor's teaching ability.

   Rating________

   Rate your instructor's skills as a microscopist.

   Rating________

   Rate your instructor's knowledge of (forensic) microscopy.

   Rating________

6. Would you recommend this course to others in your laboratory?

   Yes______ No________

7. What percentage of the material taught will you use when you return to your home laboratory?

   ______%

8. How much have your microscopy skills changed as a result of this training workshop? If the course has helped you, choose a positive percent. If not, choose a negative percent. (For example, -25% = you are 25% worse, or +25% = you have improved 25%.)

   ________ +/- sign ________ percent

9. What did you like most about the course?

10. What did you like least about the course?

11. What suggestions do you have that might improve the course?

12. Was the grading fair? Yes______ No________

    Comments:

13. What topics or techniques would you like to see offered in future workshops relating to forensic microscopy?

14. What other workshops and/or conferences would you like to see offered by FSF?

Additional Comments or Suggestions:

Workshop location ______________________________

Date ______________

APPENDIX J

MICROSCOPY WORKSHOP EVALUATION

INSTRUCTORS - SITE COORDINATORS - WSC MEMBERS

Date:

Site:

Your Role(s): Instructor_____ Site Coordinator_______ Member WSC_____

Briefly describe any problems that occurred at this workshop (e.g., facilities, location, supplies, students, staff, advanced planning, accommodations, administration, etc.).

How were they resolved?

Did the students seem satisfied with the manner in which the workshops were conducted? Were you satisfied? Were the students prepared for class?

Were your colleagues competent and helpful in their roles of instructor, site coordinator, or regional WSC member, respectively?

Additional Comments/Suggestions:

McCRONE RESEARCH INSTITUTE
2508 SOUTH MICHIGAN AVENUE
CHICAGO, ILLINOIS 60616 USA
TELEPHONE 312/842-7105

A NOT-FOR-PROFIT CORPORATION
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APPENDIX K

Your microscopy proficiency test results were as follows:

Sample #	Identity	Your results	Comments
A-			
B-			
F-			

Your results for the organic explosive and fiber unknowns are good enough but you also need to identify an inorganic explosive correctly before we can award you a certificate.

We hope that you will give it another try and are enclosing another inorganic unknown for you to identify. We look forward to hearing from you -- your correct answer will earn your certificate.

Sincerely yours,

Lucy B. McCrone

Enclosure: Sample No. A-

APPENDIX L

"OTHER WORKSHOP" TABULATIONS

Category	Frequency
fibers	63
hair	54
soils/minerology	44
paint	36
drugs	33
explosives	25
plant materials	22
glass	18
microchemical tests	16
wood	13
serology	
scanning electron microscopy	7
microcrystal tests	
hot stage	6
firearms	
trace evidence	5
phase	
arson	4
forensic microscopy	
dispersion staining/staining	
fusion techniques	
building materials	3
comparative microscopy	
polymers	
electrophoresis	
instrumentation	
crystallography	
diatoms	
toolmarks	
biologicals	
paper	
compensators	2
microphotography	
interference	
rubber	
industrial particulates	
infrared	
plastics	
insect fragments	
crime scene processing	
chromatography	
x-ray diffraction	
thermal methods	
microscopy	
advanced microscopy	
gunshot residue	
tissue identification	
micro-sampling	
slide preparation	
fiber dyes	1

Category	Frequency
gunpowder	
bone	
industrial products	
advanced polarized mic.	
double variation	
filters	
fluorescence	
ultra-violet	
refractive index	
crystal morphology	
blood typing	
airborne particulates	
clothing	
geog. location of biological materials	
foodstuffs	
adhesives	
oil and grease	
printing	
stains	
ballistics	
spectroscopy	
crystal tests	
forensic statistics	
separation techniques	
basic microscopy	
x-ray emission spectroscopy	
birefringence	
bullets	
court testimony	
ink, paper	
microscopy prof. tests	
pollens	
dispersion staining	
powder patterns	
serial no. restoration	
ion microprobe	
pyrolysis G.C.	

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AND THE
McCRONE RESEARCH INSTITUTE

FORENSIC MICROSCOPY WORKSHOPS

certify that

has successfully completed an intensive course of instruction in

Forensic Microscopy

given by the McCrone Research Institute

Presented this ________ *day of* ______________

Walter C. McCrone McCrone Research Institute	Ira T. Silvergleit Project Director	Joseph L. Peterson Project Supervisor

Grant administered by the Forensic Sciences Foundation, Inc.
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Law Enforcement Assistance Administration
United States Department of Justice

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AND THE
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Forensic Microscopy
of Soils

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certify that

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Forensic Microscopy
of Botanicals

given by the McCrone Research Institute

Presented this _______ day of ______________

Walter C. McCrone McCrone Research Institute	Ira T. Silvergleit Project Director	Joseph L. Peterson Project Supervisor

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