AMERICAN BOARD OF CRIMINALISTICS
"Professional Competency Certification in Criminalistics"

Study Guide for the Trace Evidence-Hairs and Fibers Certification Examination

Introduction

Your study guide consists of a Job Description, a list of Knowledge, Skills, and Abilities (KSAs), References, and 20 Sample Question primer for the examination.

- The **Job Description** describes the education, background, training, and specific duties of an analyst in each discipline.
- The **KSAs** have ten major sections. Sections I-IX cover the core knowledge and skills expected of every forensic scientist and comprise 40% of the examination. Section X, consisting of the specific, discipline related, in-depth, upper level knowledge, skills, and abilities will make up 60% of the examination. Please note that the sub-categories listed under the capital letters in the KSAs are examples and are not meant to be all-inclusive, or to indicate that there will necessarily be a question on the examination from every sub-category.
- The **References** are broken into core references and discipline-related references. The core references are identical for all the ABC examinations. The discipline-related references are specific to each discipline.
- There are twenty **Sample Questions** to give you an idea of the range of content and difficulty that will appear on the examination. For further information, please see "Introduction to ABC Certification Examinations."

Study Guide for the Trace Evidence-Hairs and Fibers Certification Examination

Job Description

A qualified trace (hair and fiber) analyst must be able to:

- Characterize and compare human and animal hairs, through light microscopy.
- Characterize and compare synthetic fibers using microscopy and, when appropriate, chemical and/or instrumental means of analysis.
- Characterize and compare natural fibers using microscopy.
- Characterize and compare textile specimens.
- Characterize and compare cordage specimens.
- Recognize, collect, secure, and preserve physical evidence.
- Recognize the potential for other forensic examinations in areas outside an area of specialization, prioritize the sequence of examinations, and handle evidence accordingly.
- Observe safe practices to insure the safety of analyst and co-workers.
- Engage in impartial and ethical work practices.
- Be proficient in the use and maintenance of laboratory instrumentation.
- Evaluate and interpret results of physical and instrumental analyses.
- Thoroughly and accurately produce documentation to support results and conclusions.
- Testify under oath as to analytical processes, results, and conclusions.
- Recognize and employ quality assurance measures to ensure the integrity of the analyses.

Study Guide for the Trace Evidence-Hairs and Fibers Certification Examination

Knowledge, Skills, and Abilities

I. History
   A. Evolution of practice
   B. Significant historical figures (e.g., Locard, Gross, Orfila, Kirk)

II. Crime Scene Preservation
   A. Securing
   B. Isolating
   C. Recording
   D. Searching
   E. Recognition of evidentiary value
   F. Safety

III. Crime Laboratory Operations – Overview
   A. Laboratory Disciplines
      1. Forensic biology
      2. Controlled substances
      3. Trace analysis
      4. Toxicology
      5. Latent fingerprints
      6. Questioned documents
      7. Fire debris
      8. Firearms/Toolmarks
      9. Digital evidence
   B. Evidence Associated with each discipline

IV. QA/QC
   A. Accreditation, Certification, Standardization
      1. Laboratory accreditation
         a) Audit Trails
         b) Accrediting bodies
         c) ISO 17025
         d) DAB standards
         e) ASCLD/LAB
      2. Personnel certification
         a) ABC
         b) IAAI
         c) IAI
         d) ABFT
         e) AFTE

3. Standardization
    a) ASTM
    b) UN
    c) TWG/SWG

B. QA/QC Application
1. Non compliant data
2. Documentation evaluation
3. Validation and verification
4. Linearity
5. Limits of detection
6. Limits of quantitation
7. Limits of reporting
8. Negative and positive controls
9. Calibrators
10. Estimate of uncertainty
11. Traceability
12. Corrective and preventative actions
13. Proficiency testing
14. Confidence interval/Confidence limits

C. Document/Data Management
1. Databases
2. LIMS
3. Case document preservation/integrity

V. Safety

A. Chemical Hygiene
1. Safety labeling (MSDS)
2. Communication plans

B. Universal Precautions
1. Blood-borne pathogens
2. Personal protective equipment

C. Hazardous Waste/Biohazardous Waste Handling
1. Spill control

VI. Legal

A. Decisions/laws
1. Frye
2. Daubert/Kumho
3. Brady

B. Legal terms
1. Chain of custody
2. Discovery
3. Voir Dire

4. Duces Tecum
5. Subpoena

C. Court Testimony
1. Monitoring
2. Courtroom etiquette

D. Procedural Law
1. Hearings, trials, appeals
2. Advocacy, burden of proof
3. Subpoenas and affidavits
4. Rules of Evidence

VII. Ethics

A. ABC Code of Professional Ethics
1. Conflict of interest
2. Professional integrity
3. Objectivity
4. Professional obligations

VIII. Evidence Handling

A. Evidence Recognition and Collection
1. Prioritization based on circumstance
2. Sampling
3. Preservation

B. Evidence Classes (Class/Individual)
1. Exclusionary evidence
2. Identification
3. Direct vs. indirect evidence
4. Tangible vs. latent evidence

C. Evidence Preservation
1. Chain of custody
2. Alteration/degradation
3. Storage(long term/short term)

D. Evidence Packaging
1. Proper sealing
2. Types of packaging

IX. General Science Terms and Principles

A. Definitions and applications
1. Scientific Method

B. General Chemistry Concepts
1. Nomenclature (IUPAC)
2. Type of molecules (e.g., aromatics, isoalkanes)
3. Atomic, molecular weights
4. Acids/bases
5. Periodic Table

6. Elemental composition
7. Bonding
    a) Ionic
    b) Covalent
    c) Hydrogen
    d) Van der Waals
    e) Stereoisomer
    f) Enantiomer

C. General Biology Concepts
1. Cell structure
2. Genetics
3. Botany
4. Characteristics of body fluids

D. General Physics Concepts
1. Energy
2. Electromagnetic spectrum
3. Force

E. General Physiology and Anatomy Concepts

F. General Statistics
1. Mean
2. Median
3. Mode
4. Standard deviation
5. Variability
6. Population characteristics

G. Stoichiometry

H. Logic
1. Critical thinking
2. Inductive and deductive reasoning

I. Metric System
1. Metric to metric conversion
2. Metric to English conversion

X. Forensic Science Applications for Trace (Hairs and Fibers) Analysis

A. Principles and concepts

1. Properties of hairs and fibers that allow their characterization, comparison, identification
    a. Phylogenetic characteristics of human hair, common domestic animals, apparel furs, and game animals
    b. b. Racial and somatic characteristics of human hairs
    c. Macroscopic and microscopic features of hair
    d. Chemical treatments to hairs

e. Hair diseases and environmental damage to hair
f. Hair structure and microstructure
g. Hair chemistry
h. Biology of hair growth and loss (deposition)
i. DNA in animal and human tissue and hairs
j. Biology of vegetable fibers
k. Microscopic structure of natural fibers and mineral fibers used in textiles, cordage, and other applications
l. Chemistry of mineral fibers
m. Chemistry of manufactured fiber polymers
n. Manufactured fiber production
o. Microscopic features of man-made fibers
p. Dyes and additives used in fibers and textiles
q. Man made fiber spinning and forms
r. Fiber mechanics and damage

2. Suitability of hairs for nuclear or mitochondrial DNA analysis
3. Methods of production/manufacture of fibers and textiles and how they affect the product characteristics
4. Current Information
    a. Scientific literature applicable to the examination of hairs and fibers
    b. Attendance at workshops, classes, technical or professional meetings for current manufacturing processes, application techniques, uses, and methods of analysis for fibers
    c. Critical comparison of old and new techniques in hair and fiber analysis

B. Occurrence of Hair and Fiber Evidence
    1. Loose fibers
    2. Textiles
    3. Cordage
    4. Human and animal hairs
    5. Building materials and other industrial uses
    6. Brushes and furs

C. Evolution of the discipline
    1. History of the development of fibers as forensic evidence
    2. History of the use of hairs as forensic evidence

D. Accepted standards and practices
    1. Methods, procedures, tests commonly used in the analysis of hairs and fibers
    2. ASTM, SWGMAT, NIST, SWGDAM

E. Process Analysis
   1. Evaluation of other trace evidence (dust, aggregates, pollen, blood, cosmetics, paint, etc.) found with hair and fiber evidence
   2. Consideration of the effects of environmental and mechanical damage to hairs and fibers
   3. Consideration of the meaning of the deposition of hairs and fibers including transfer (primary and secondary) and plucking
   4. Consideration of retention and/or persistence properties with respect to hairs, fibers, and the pertinent substrates
   5. Case evaluation to ensure the analysis addresses the relevant forensic issues
   6. When appropriate, determination of the growth phase of a hair, whether forcibly removed, suitability for DNA analysis, artificial hair treatments
   7. Development of an analysis strategy for the hair and/or fiber evidence

F. Results and Conclusions
   1. QA/QC
      a. Use and maintenance of hair and fiber reference libraries
      b. Verification of associations
   2. Reporting
      a. Construct a report which may include: chain of custody information, description of hairs/fibers, nature of analyses, results of tests, conclusions
      b. Justification for opinion (positive or negative association or an inconclusive result)
      c. Case Management
         a. Maintenance of documents and data for discovery
         b. Technical review

G. Light Microscopy
   1. Theory and Application
      a. Principles of light microscopy
      b. Nomenclature
      c. Types of light microscopes
      d. Optical properties of trace evidence materials such as refractive indices, birefringence, color, etc.
   2. Procedures and Methods
      a) Illumination techniques such as polarized light, phase contrast, differential interference contrast, incident and reflected light, fluorescence, darkfield, brightfield
      b) Characterization and comparison of hairs/fibers by light microscopy
      c) Making microscopical measurements

d) Mounting media
e) Photomicrography
f) Cross sectioning and longitudinal sectioning techniques

3. Results and Interpretation
4. QA/QC
    a) Optimization of illumination and alignment
    b) Maintenance of the microscope
    c) Measurement of standards
    d) Comparison of standards across a comparison microscope

H. Infrared, Raman, Visible, Ultraviolet, Fluorescence, Near Infrared spectrometry

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

I. Electron microscopy (scanning and transmission)

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

J. Gas Chromatography with various detectors and sample introduction techniques (mass spectrometers, pyrolysis)

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

K. Other techniques used in hair and fiber analysis

1. LC/MS and CE/MS for dyes/additives
2. TLC for dyes

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References

Listed below are the references for the Trace Evidence-Hairs and Fibers Certification Examination. Small numbers of examination questions may have been drawn from a variety of other sources including general instrumental or chemistry text. Similar information may be obtained by studying earlier or later editions of the listed works, as well as other works covering the same topics.

Core

(40% of examination content)

The following texts were used for the generation of test questions for the CORE knowledge. Applicants are encouraged to familiarize themselves with information provided by these texts as that information relates to the KSA (knowledge, skills, and abilities) outlined in this study guide.

Techniques of Crime Scene Investigation, 7th Edition, by Fisher, B.J. (Boca Raton: CRC Press, 2004) ISBN 0-8493-1691-X.

Criminalistics, An Introduction to Forensic Science, 7th Edition (or higher), by Saferstein, R. (Upper Saddle River, NJ: Prentice Hall, 1998) ISBN 0-13-592940-7.

Forensic Science Handbook, Volume I, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9.

Forensic Science Handbook, Volume II, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2004) ISBN 0-13-112434-X.

Forensic Science Handbook, Volume III, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 1993) ISBN 0-13-325390-2.

Fundamentals of Forensic Science, by Houck, M., Siegel, J. (Burlington, MA: Elsevier Academic Press, 2006) 0-12-356762-9.

Forensic Chemistry, by Bell, S., (Upper Saddle River, NJ: Pearson Prentice Hall, 2006) ISBN 0-13-147835-4.

"The Rules of Professional Conduct" supplied by the American Board of Criminalistics. www.criminalistics.com

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ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories. International Organization of Standards, (ISO copyright office, Switzerland, 2005)

Discipline-related

(60% of examination content)

In addition to the core information provided in the text above, the following texts are specific to the discipline (hairs and fibers) portion of this examination.

Polarized Light Microscopy by McCrone, W., McCrone, L., Delly, J. (Chicago, Illinois: Microscope, 2005) ISBN 0250402629.

Atlas of Human Hair: Microscopic Characteristics, by Ogle, R. and Fox, M. (Boca Raton, Florida, CRC Press, 1999). ISBN 0-84938134-7

Forensic Examination of Fibres, Second Edition, Edited by Robertson, J., and Grieve, M. (Philadelphia, PA, Taylor & Francis, 1999).

Forensic Examination of Hair, Edited by Robertson, J... (Philadelphia, PA, Taylor & Francis, 1999).

SWGMAT Forensic Human Hair Examination Guidelines, US Dept. of Justice, April 2005

ASTM No. E2224-02 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

ASTM E-620-04 Standard Practice for Reporting Opinions of Scientific or Technical Experts.

ASTM E 2225-02 Standard Guide for Forensic Examination of Fabrics and Cordage.

ASTM E 2228-02 Standard Guide for Microscopic Examination of Textile Fibers

Forensic Science Communications April 1999 Volume 1 Number 1, Introduction to Forensic Fiber Examination Guidelines, FBI, April, 1999.

Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators by Petraco, N. and Kubic, T., (Boca Raton, Florida, CRC Press, 2003) ISBN 0849312450.

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A new generic fiber type, *Forensic Science Communications*, *56(3):2003*Author: Heather A. Velez

Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs, *Forensic Science Communications*, 6(1):2004

From the Core readings listed, especially close attention should be paid to the following:

Forensic Science Handbook, Volume I, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9:

- Chapter 3 - *Forensic Applications of Mass Spectrometry*
- Chapter 5 - *Foundations of Forensic Microscopy*
- Chapter 6 - *Visible Microscopical Spectrophotometry in the Forensic Sciences*
- Chapter 7 - *The Forensic Identification and Association of Human Hair*

Forensic Science Handbook, *Volume II*, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2005) ISBN 0-13-112434-X.

- Chapter 3 - *Forensic Capillary Gas Chromatograpy*
- Chapter 5 - *Microscopy and Microchemistry of Physical Evidence*
- Chapter 6 - *An Introduction to the Forensic Aspects of Textile Fiber Examination*

Forensic Science Handbook, Volume III, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 1993) ISBN 0-13-325390-2.

- Chapter 2 - A Guide to The Analysis of Forensic Dust Specimens
- Chapter 3 - Forensic Applications of Infrared Spectroscopy
- Chapter 4 - Infrared Microscopy and its Forensic Applications

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Sample Questions

1. The primary reason for proving "chain of custody" on a particular item in court is to:

    a. Authenticate the item.
    b. Show how many people handled the item.
    c. Show how long it was in each person's possession.
    d. Deter or prevent unauthorized individuals from handling the evidence.

2. Which of the following spectral regions has the highest energy?

    a. Ultraviolet.
    b. Infrared.
    c. Radio.
    d. Visible.

3. When handling biological materials, which of the following is the most reasonable approach to take?

    a. Precautions are not normally necessary for sample handling since transmission of disease has not been shown to occur from such contact.
    b. Precautions need only be taken when samples are in the liquid state since disease vectors are no longer viable upon drying.
    c. Precautions should be taken regardless of the condition or the origin of the samples being handled.
    d. Precautions need only be taken with unknown stains and liquids since preservatives and chelating agents present in reference samples will kill any communicable disease.

4. Which of the following actions is not forbidden by the ABC Code of Professional Conduct?

    a. Embellishing one's qualifications when testifying.
    b. Utilizing a secret method.
    c. Refusing to honor a subpoena duces tecum.
    d. Interpreting equivocal results based only on an employer's wishes.

5. Upon reviewing your notes for a court appearance in one week, you realize that there is a clerical error and two results have been reversed. Which of the following is the best course of action?

    a. Issue a corrected report including the date of the correction and testify to the error if asked.
    b. Immediately notify the attorney and issue a report which makes the correction clear.
    c. Immediately make an entry in your notes as to your discovery and correct it in testimony if asked.
    d. Correct the error in testimony if asked, but make no additions or alterations to your notes.

6. Which of the following garments would be the most suitable for collection of trace evidence by using a tape lift technique?

    a. Nylon shell windbreaker
    b. Mohair sweater
    c. Cotton/polyester blend dress shirt
    d. Pair of blue denim trousers

7. Which of the following properties of synthetic fibers require the use of a polarized light microscope for their determination?

I. Sign of elongation
II. Birefringence
III. Extinction
IV. Modification ratio
V. Refractive index

    a. I, II and III, only
    b. V, only
    c. I and V, only
    d. II, III and V, only

8. A burglar enters a residence by breaking a window in the front door, reaching through the door and turning the knob. He is confronted by the angry homeowner, and the burglar and the homeowner get into a struggle in which the homeowner wrestles the burglar to the ground. The burglar then pushes the homeowner backwards and turns and runs out the door. Ten minutes later, a suspect is apprehended. The suspect's clothing, including a sweatshirt, a pair of Levis, and a pair of athletic shoes, are seized by the arresting officer who submits them to the lab for examination. The officer also has obtained and submitted to the laboratory the following items from the crime scene: A hammer, a piece of the broken glass from the front door, the bathrobe worn by the homeowner, and a sample of the carpet in the entryway. If you were asked by the investigator, which potential physical evidence in this case would be of greatest probative value to him?

    a. The mutual fiber transfers between the suspect's clothing and the homeowner's bathrobe
    b. The glass fragments on the suspect's clothing
    c. The glass fragments on the hammer
    d. Carpet fibers found embedded in the soles of the suspect's shoes

9. What is phaeomelanin?

    a. A reddish-brown to yellow pigment occurring in hair.
    b. A sulfur-containing fibrous protein.
    c. A condition of hair characterized by brittle hair with a clean break.
    d. A brown pigment occurring in hair.

10. Consider the hypothetical cylindrical fiber 15 micrometers in diameter, which has n (perpendicular) = 1.570, which exhibits parallel extinction and a first order red interference color (in its center) at the position of maximum brightness. When the fiber is aligned perpendicular to the slow ray of the compensator (quarter wave plate), a blue color is noted. For the purposes of this question assume that the optic axis lies along the fiber axis. The n(parallel) for this fiber would be approximately:

    a. 1.575
    b. 1.515
    c. 1.535
    d. 1.605

11. When performing refractive index determinations, the Becke line will always move into the material of higher refractive index when

a. The distance between the objective and the specimen is increased.
b. The distance between the objective and the specimen is decreased.
c. The temperature of the mounting medium is lowered
d. Full-aperture Kohler illumination is used.

12. The refractive index for a mounting medium for a microscopic examination of human hair should be approximately

a. 1.55
b. 1.66
c. 1.60
d. 1.50

13. A graying hair is often associated with:

a. decrease in diameter
b. an increase in diameter
c. shouldering
d. undulation

14. The property of an optically anisotropic substance by which it exhibits different brightness and/or color in different vibration directions is called _____.

a. dispersion
b. pleochroism
c. isotropic
d. extinction

15. Which one of the following materials would be unsuitable as a sample support medium, (slide) for small peels of paint when analyzing them by transmitted Fourier Transform Infrared (FTIR) microspectrophotometry?

a. potassium bromide
b. silver chloride
c. silicon dioxide
d. cesium iodide

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16. A new fiber whose generic name is polyactide, known as PLA, is based on:

a. lactic acid esters from naturally occurring sugars
b. a new variety of a fluorinated hydrocarbon-based fiber
c. a reduced polyamide polymer
d. recycled paper fibers

17. Which collection method for trace evidence has the highest possibility of contamination?

a. adhesive taping
b. scraping
c. vacuuming
d. swabbing

18. Which of the following terms is the BROADEST category describing chemical compounds that have the same chemical formula and the same atomic bond arrangement, and differ only in the orientation of the molecules in three-dimensional space?

a. stereoisomers
b. diastereoisomers
c. enantiomers
d. isomers

19. Refractive index can be defined as:

a. The ratio of velocity of light in a vacuum to that in any medium.
b. The process of separating light into component colors.
c. The bending of a light wave because of a change in velocity.
d. The light halo that disappears when the medium and the specimen have similar light dispersion

20. An animal hair with an undulating shaft and a wine-glass shaped root is MOST likely to be from a _____.

a. rabbit
b. dog
c. cat
d. deer

Answers can be found in the references.