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"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

Introduction

Your study guide consists of a Job Description, a list of Knowledge, Skills, and Abilities (KSAs), References, and 10 Sample Questions for the exam.

- 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 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. There will not necessarily be a question on the exam 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 ten S**ample Questions** to give you an idea of the range of content and difficulty that will appear on the exam. For further information, please see "Introduction to ABC Certification Examinations."

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

Job Description

A Qualified Forensic Biologist must be able to:

- Apply principles of General Biology, Cell Biology, Molecular Biology, Biochemistry, Genetics, and Statistics/Population Genetics to the analysis of biological materials.
- Apply chemical, immunological, microscopic and / or molecular biological methods to assess, where possible, the physiological nature and species of origin of unknown biological material.
- Apply specialized techniques to isolate and purify nucleic acids from various biological tissues, fluids, and complex mixtures.
- Apply specialized techniques to the quantification of DNA.
- Apply specialized techniques to the elucidation of polymorphic variations in biological genomes.
- Apply principles of population genetics to the assessment of polymorphic variations.
- Stay abreast of current developments in the field of forensic biology.
- Recognize, collect, secure, and preserve physical evidence.
- Recognize the potential for 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.
- Demonstrate proficiency in the use and maintenance of laboratory instrumentation.
- Evaluate and interpret results of physical and instrumental analysis.
- Thoroughly and accurately produce documentation to support results and conclusions.
- Effectively communicate scientific results through written reports
- Testify under oath as an expert witness, providing information on analytical processes, results, and conclusions.
- Recognize and employ quality assurance measures to ensure the integrity of the analyses.
- Understand and be able to apply the validation process for the introduction of new DNA technologies into the forensic laboratory.
- Demonstrate familiarity with the documents Quality Assurance Standards for Forensic DNA Testing Laboratories and Quality Assurance Standards for Forensic Databanking Laboratories.
- Understand uses and practices of the Combined DNA Index System (CODIS.)
- Conduct second reads and technical reviews of the analytical work of other forensic biologists.

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology 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) FBI Quality Assurance Standards (QAS)

      2. Certification of personnel
         a) ABC
         b) IAAI
         c) IAI
         d) ABFT
         e) AFTE
         f) ABFDE
         g) BFDE
         h) IACIS

Study Guide for the Molecular Biology Certification Examination

3. Standardization
    a) ASTM
    b) UNODC
    c) TWG/SWG
    d) OSAC
    e) ASB

B. QA/QC Application
1. Noncompliant 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. Measurement of Uncertainty
11. Traceability
12. Corrective and preventative actions
13. Proficiency testing
14. Confidence interval/confidence limits
15. Sampling plans / sample selection

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

V. Safety
A. Chemical Hygiene
1. Safety labeling (SDS)
2. Globally Harmonized System of Classification and Labeling of Chemicals (GHSCLC)
3. Communication plans

B. Universal Precautions
1. Bloodborne 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
4. Melendez-Diaz

Study Guide for the Molecular Biology Certification Examination

B. Legal terms
    1. Chain of custody
    2. Discovery
    3. Voir dire
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 Rules of Professional Conduct
    1. Conflict of interest
    2. Professional integrity
    3. Objectivity
    4. Professional obligations

VIII. Evidence Handling
A. Evidence Recognition and Collection
    1. Prioritization
    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

Study Guide for the Molecular Biology Certification Examination

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
    7. Confidence Interval
    8. Bayesian Theory

G. Stoichiometry

H. Logic
    1. Critical thinking
    2. Inductive and deductive reasoning
    3. Contextual bias

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

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

Forensic Science Applications for Molecular Biology

A. Principles and concepts

1. Biological Screening Tests
    a) Locating body fluid stains
        (1) Visual techniques (daylight, bright or oblique lighting, Alternate Light Source, IR)
        (2) Mapping techniques
    b) Amylase/saliva
        (1) Physiology of saliva
        (2) Detection methods
        (3) Interpretation- controls, false positives, and false negatives
    c) Blood
        (1) Physiology of blood
        (2) Detection methods (e.g. presumptive chemical tests such as luminol, o-tolidine, etc.)
        (3) Confirmatory tests
        (4) Interpretation- controls, false positives and false negatives
    d) Feces
        (1) Physiology of feces
        (2) Detection methods
        (3) Interpretation- controls, false positives and false negatives
    e) Semen
        (1) Physiology of semen
        (2) Chemical detection methods (Acid Phosphatase, choline, spermine, P30, MHS-5)
        (3) Morphology of spermatozoa
        (4) Post coital intervals in body cavities
        (5) Azospermic semen stains
        (6) Interpretation- controls, false positives and false negatives
    f) Urine
        (1) Physiology of urine
        (2) Detection methods
        (3) Interpretation- controls, false positives and false negatives
2. Anatomy, Physiology, Reproductive Biology
    a) Biology and Organization of organs and tissues

Study Guide for the Molecular Biology Certification Examination

b) Cytology and Biochemistry of physiological fluids
c) Reproductive Biology

3. Cellular and Molecular Biology
   a) Cell Morphology
   b) Cells and Chromosomes
   c) Chromosomal organization
   d) Cellular DNA content
   e) Cell Division
   f) DNA Structure
   g) Transcription and Translation
      (1) Gene expression regulation
      (2) Cell differentiation and specialization
      (3) DNA that is not expressed
      (4) Levels of gene expression control
         (a) Transcriptional
         (b) Processing
         (c) Translational
   h) Replication
      (1) DNA organization
      (2) Replication forks and bubbles
      (3) Enzymes involved in DNA replication
      (4) Proof-reading mechanisms
   i) Mutation mechanisms and rates
      (1) Kinds of mutations
         (a) Substitutions and Frameshifts
         (b) Unstable trinucleotide repeats and other repeat mutation mechanisms
         (c) Unequal crossing over
         (d) Insertions/Deletions
      (2) Agents of mutations
         (a) Chemical mutagenesis
         (b) Radiation mutagenesis
      (3) Repair
4. Genetics
   a) Mendelian (autosomal)
      (1) Rules of Inheritance
      (2) Human Pedigrees
   b) Non-mendelian
      (1) Y-chromosomal
      (2) Mitochondrial
   c) Cytogenetics-Chromosomal Abnormalities

Study Guide for the Molecular Biology Certification Examination

(1) Nondisjunction-Mitotic and Meiotic
(2) Chromosomal abnormalities
d) Genetic diseases

5. Developmental Biology
   a) Genetics of Development
      (1) Embryonic Development
      (2) Sexual Development
6. Biochemical Kinetics
   a) Enzymes as catalysts
   b) Substrates and Active sites
   c) Effect of pH
   d) Metabolic pathways
   e) Oxidation and Reduction
   f) Directing metabolism
   g) Control of enzyme synthesis
7. Population Genetics
   a) Hardy Weinberg
   b) Mechanisms of Evolution
      (1) Mutation
      (2) Selection
      (3) Genetic Drift
      (4) Migration/Gene Flow
   c) Statistics and Probability
      (1) Tests for independence of inheritance
      (2) Pd and Pi
      (3) Population substructure-calculations-NRCII
      (4) Confidence intervals
   d) Population databases
8. Phylogeny and Evolution
   a) Basics of Phylogenetic analysis
   b) Human evolution- Molecular Clock
   c) Evolution of humans
   d) Anthropology - migrations of human populations
   e) Genetic markers and non genetic markers
9. Non-human Molecular Applications
   a) Animal forensic DNA applications
   b) Plant forensic DNA applications
   c) Microbial DNA applications

B. Types of evidence
   1. Criminal
   2. Non-criminal

Study Guide for the Molecular Biology Certification Examination

3. Missing-person/mass disaster
4. Kinship
5. Databanking
6. Non-human

C. Evolution of the discipline
1. Antigen and immunological systems
2. Protein and enzyme polymorphisms
3. RFLP
4. PCR, qPCR, RT-PCR
5. Genetic markers
6. RNA gene expression techniques
7. Automation

D. Accepted standards and practices
1. Quality Assurance Standards for Forensic DNA Laboratories
2. Quality Assurance Standards for Forensic Databank Laboratories
3. SWGDAM
4. CODIS
5. Validation for introduction of new technologies

E. Casework documentation and reporting (Results and Conclusions)
1. Case Management
a) Common practices used to evaluate requests for analysis
b) Common practices used to establish a case record
2. Process analysis
a) Consideration of analytical limitations in selection of procedure(s) and use in formulating appropriate conclusions
b) Required testing controls
c) Common elements among and documentation of analytical procedures
d) Practices used for interpretation of data
3. Artificial Intelligence
a) Second Read Software and automation
4. Assessing source and weight of evidence
a) Physiological attributes
b) Genotype profiling (single-source, mixture deconvolution)
c) Inclusion probabilities (Random Match, Combined Probabilities of Inclusion/Exclusion) and

Study Guide for the Molecular Biology Certification Examination

Likelihood estimates – application of SWGDAM guidelines

5. Reporting
    a) Requirements
    b) Quantitative / Qualitative Conclusions
    c) Reviews (Technical and Administrative)

F. Visualization tools/techniques
1. Microscopy
    a) Theory
    b) Application/Processes
    c) Interpretation/Results
2. Electrophoresis
    a) Theory
    b) Application/Processes
    c) Interpretation/Results
3. Fluorescence
    a) Theory
    b) Application/Processes
    c) Interpretation/Results

G. Isolation and purification of nucleic acids
1. Theory
2. Application/Processes
3. Interpretation/Results

H. Quantification (yield gel, hybridization, real time qPCR)
1. Theory
2. Application/Processes
3. Interpretation/Results

I. Polymerase Chain Reaction
1. Theory
2. Application/Processes
3. Interpretation/Results

J. DNA Typing Technology
1. Fragment Analysis / Short Tandem Repeat Analysis
    a) Theory
    b) Application/Processes
    c) Interpretation/Results
2. Sequence Analysis
    a) Theory
    b) Application/Processes
    c) Interpretation/Results
3. SNP Analysis
    a) Theory
    b) Application/Processes

Study Guide for the Molecular Biology Certification Examination

c) Interpretation/Results

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

References

The following recommendations are made for those who wish to prepare to take the Molecular Biology Certification Examination. Some questions may have been drawn from a variety of other sources including general instrumental or chemistry texts. 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 exam 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, 2005) 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.

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

Discipline-specific (60% of exam content)

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

The following recommendations are made for those who wish to prepare to take the Molecular Biology Certification Examination. The following texts are specific to the discipline (molecular biology) portion of this examination.

Books

Any basic genetics textbook.

Any basic biochemistry text book and molecular biology textbook.

Sourcebook in Forensic Serology, Immunology, and Biochemistry, 1989 Update website: http://www.ncjrs.gov/App/Publications/abstract.aspx?ID=160880

It is a collection of PDF files.

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

Chapter 1: "Legal Aspects of Forensic Science"
Chapter 10: "Modern Forensic Biology"

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

Chapter 8: "The Identification and Individualization of Semen and other Body Fluids"

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

Chapter 7: "Forensic DNA Typing of Highly Polymorphic VNTR Loci"
Chapter 8: "DNA Analysis and Biological Evidence: Applications of the Polymerase Chain Reaction."

Interpreting DNA Evidence: Statistical Genetics For Forensic Scientists, by Evett and Weir, (Sunderland, MA: Sinauer Associates, Inc., 1998) ISBN 0-87893-155-4 (paper)

Chapter 1: "Probability Theory" (pages 1-21)
Chapter 2: "Transfer Evidence" (pages 22-42)
Chapter 4: "Population Genetics" (pages 79-131)

AMERICAN BOARD OF CRIMINALISTICS
"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

Chapter 6: "Parentage Testing" (pages 163-187)

Principles of Population Genetics, by Hartl and Clark, (Sunderlund, MA: Sinauer Associates, Inc., 1989) ISBN 0-87893-302-6

The Evaluation of Forensic DNA Evidence, by National Research Council (Washington, D.C.: National Academy Press, 1996) ISBN 0-309-05395-1

Forensic DNA Typing, 2nd Edition, by Butler, John M. (Elsevier Academic Press, 2005) ISBN 0-12-14792-8.

Advanced Topics in Forensic DNA Typing: Methodology, by Butler, John M. (Elsevier Academic Press, 2012) ISBN 978-0-12-374513-2

Literature

We recommend that you download and be familiar with the publications listed below, and that you stay current in the field through periodic review of relevant articles available in the listed peer journals and government website.

1. *Journal of Forensic Science*
2. *American Journal of Human Genetics*
3. *Biotechniques*
4. *Forensic Science International: Genetics*
5. *International Journal of Legal Medicine*
6. *NIST STRbase Website:* STR bibliography, validation and background data for short tandem repeats, Standard Reference Materials (SRM 2372, 2391, 2392, 2395) and links to other sites. (Http://www.cstl.nist.gov/div831/strbase/)
7. *SWGDAM website* (http://www.swgdam.org/)

Publications:

"SWGDAM Interpretation Guidelines for Autosomal STR Typing by Forensic DNA Testing Laboratories; approved January 2010" (or most recent)
"SWGDAM Y-Chromosome Short Tandem Repeat (Y-STR) Interpretation Guidelines" (or most recent)

"SWGDAM Guidelines for Mitochondrial DNA (mtDNA) Nucleotide Sequence Interpretation" (published in Forensic Science Communications, April 2003 – Volume 5

Study Guide for the Molecular Biology Certification Examination

Number 2) (or most recent)

"SWGDAM Validation Guidelines for Forensic DNA Analysis Methods: Approved December 2012" (or most recent)

Quality Assurance Standards for Forensic DNA Testing Laboratories, effective 9-1-2011 (or most recent)

Quality Assurance Standards for Convicted Offender DNA Databasing Laboratories, effective 9-1-2011 (or most recent)

"NDIS Operational Procedures Manual", and "CODIS and NDIS Fact Sheet"
http://www.fbi.gov/about-us/lab/biometric-analysis/codis

AMERICAN BOARD OF CRIMINALISTICS

"Professional Competency Certification in Criminalistics"

Study Guide for the Molecular Biology Certification Examination

Sample Questions

1) Which of the following best describes the value of field kits for the chemical testing of controlled substances?

   A. They remove the necessity for laboratory analysis.
   B. They are presumptive tests.
   C. They have questionable reliability.
   D. They allow the officer to make a field identification.

2) 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.

3) You receive an envelope containing a semi-automatic pistol for an operability check. You open the envelope to examine the weapon. You first remove a fully loaded magazine. The weapon is now:

   A. Potentially still loaded and unsafe.
   B. Unloaded and safe.
   C. Potentially still loaded but safe.
   D. Rendered safe because of a magazine disconnect.

4) What may happen if the ionic strength of an electrophoresis buffer is too low?

   A. Diffuse bands may result.
   B. The current will not flow.
   C. Electroendosmosis will increase.
   D. No separation will occur.

5) Which of the following actions is not forbidden by the ABC Rules 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.

Study Guide for the Molecular Biology Certification Examination

6) What is the range of probabilities that two genes on the same chromosome will remain together after meiosis?

A. 5% to 25%
B. 1% to 99%
C. 25% to 75%
D. 50% to 99%

7) A nucleic acid must contain a nitrogenous base and which of the following?

I. Aromatic ring
II. 4-carbon ring
III. 5-carbon ring
IV. phosphate

A. I, II, and IV
B. III and IV
C. I and III
D. I and IV

8) Which of the following factors DO NOT affect the migration of DNA fragments through an electrophoretic system?

I. pore size
II. tracking dye
III. DNA shape

A. II only
B. II and III
C. I and II
D. I and III

9) A three banded isoenzyme pattern with a 1:2:1 intensity ratio indicates a _____ protein.

A. monomeric
B. dimeric
C. trimeric
D. tetrameric

Study Guide for the Molecular Biology Certification Examination

10) What are organic compounds having the basic formula NH_2-R-COOH (where R = an aliphatic or aromatic side chain) that are polymerized to form peptides and proteins termed?

A. amino acids
B. enzymes
C. phospholipids
D. polysaccharides