Forensic Science: Issues and Direction

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Evaluation of Forensic Disciplines

- On behalf of the Laboratory Director an open invitation to visit is offered
- To view processes and discuss among scientists

Evaluation of Forensic Disciplines

- DNA as a standard model – is this wise?
- Are there lessons learned from the DNA experience or from other disciplines that could be informative?
- Good science vs legal motivation

Proper Use of DNA as a Model

- Focus on Infrastructure
- Be cautious of applying the science strictly
- May unintentionally be putting square peg in round hole

DNA Infrastructure

- National Coordination
- Peer consensus
- Scientific Working Group created
- Initially set guidelines of performance to achieve certain standards of operation and some standardization (of markers)
- Stressed beneficial concept of education, training, analytical, statistics
- Legislation – now standards (thus enforcement)
- Research partnerships – forensic, government agencies, academia, industry, national/international
- Peer review – publication, presentation
- QA, Proficiency tests, Accreditation

Creating DNA Infrastructure

- There were some difficulties, due to…
- Forensic Culture
- Adversary System is a substantial contributor to culture
- Science uses criticism constructively
- Legal arena uses criticism destructively
- Distrust is fostered
- For example, discussion of errors and limitations are often distorted
- Can be a distraction from real issues
- Need to overcome this culture by Committee recognizing this issue and making recommendations how to mitigate

Legal Debate

Thousands of innocent people in jail because of DNA typing

Thousands of innocent people in jail because of no DNA typing

Adversary System

Even though same approaches and practices…

Adversary System - Scientist Perspective
(DNA Experience)

- Courtroom v Scientific Process of Criticism
- Courtroom is not a good venue for resolving science issues
- Some said “DNA Forensic Science is not a science”
- Some said “Consensus must mean that there is a conspiracy”
- Some said “The field is corrupt”
- The best approach was to address scientific issues

REVIEW

The Coming Paradigm Shift in Forensic Identification Science

Michael J. Saks[1] and Jonathan J. Koehler[2]

Converging legal and scientific forces are pushing the traditional forensic identification sciences toward fundamental change. The assumption of discernible uniqueness that resides at the core of these fields is weakened by evidence of errors in proficiency testing and in actual cases. Changes in the law pertaining to the admissibility of expert evidence in

that different objects share a common set of observable attributes. Without the discernible uniqueness assumption, far more scientific work would be needed, and criminalists would need to offer more tempered opinions in court.

Science 2005 Vol 309: 892

Saks says “All Experts Have a Propensity to Fabricate”

- Similar criticism unsuccessfully levied against the use of DNA analyses
- About one-third of the interpretable calls in DNA analyses are exclusions
- Note: That all comparative forensic science fields have a reasonably high frequency of exclusions
- This fact would seem to conflict with the notion of data manipulation to achieve “matches”
- Forensic scientists have as much incentive in obtaining an exclusion as there is in achieving a “match”

Saks says "All Experts Have a Propensity to Fabricate"

- Fudging a "match" has dire consequences
  - very difficult to commit
  - checks and balances
  - to be very effective requires conspiracy
- We oppose intentional manipulation and when an issue arises more requirements are added
- The overwhelming majority of forensic scientists well appreciate
- The true perpetrator is still free preying on innocent victims
- The forensic scientist risks having a contrary (legitimate) scientific opinion presented in court and the media
- Ethics training can reinforce proper practices (ex: lack of candor)

Addressing Errors

- Need a strong QA program (models exist and in practice) - raises standards of operation
- Focus on areas of likely error
- Most often human error
- Most people do good jobs
- A few tend to make most of the errors
- A difference between standards and standardization
- More education and training
- As you address this issue – look to practices today not what may have been performed a decade or more ago

QA

Peer Consensus

Peer Input

Develop Guidelines

DNA is unique – DNA Identification Act –

1. Standards
2. Enforces compliance

Quality Management Guidelines for Laboratories Performing Forensic Work (for all disciplines)

- Goal is to promote development of a forensics program that is scientifically valid and rigorous
- Define criteria for development and validation of forensics methods that will support attribution for criminal investigations
  (and for exculpation)
- Need to enforce national working guidelines for quality assurance and quality control as applied to forensics

Purpose

- mandates a baseline for laboratories to structure their QA practices
- Uniformity of quality practices among labs
- Obvious benefits – fosters: communication/input/constructive criticism

Contents

- References
- Scope
- Definitions
- QA program
- Organization & management
- Personnel
- Facilities
- Sample control
- Validation
- Analytical procedures
- Equipment calibration & maintenance
- Reports
- Technical review
- Proficiency testing
- Corrective action
- Audits
- Safety
- Subcontractors

Personnel

- Job descriptions
- Training program
- Technical manager***
  - responsible for lab operations
- Examiner
  - responsible for lab report
- Technicians & support personnel

Technical Leader/Manager

- Education
- Training
- Analytical
- Not all personnel need to meet these criteria

Qualifications of Expert

- Could help guide the court better
- Maybe define these better

Analytical Procedures

- Documented procedures
- Sufficient detail

Methodology
Forensic Concerns

- Bad method done poorly
- Bad method done well
- Good method done poorly
- Good method done well,
  but not accepted in legal system

Validation

- Process to acquire necessary information to assess ability to obtain desired result, conditions, and limitations
- Must have been conducted
- Once validated, appropriate studies of limited scope for each new part…

8. VALIDATION (from Microbial Forensics)

8.1 The laboratory should use validated methods and procedures for analyses.

8.1.1 Developmental validation that is conducted should be appropriately documented.

8.1.2 Preliminary validation is the acquisition of limited test data to enable an evaluation of a method used during a biocrime or bioterrorism event. If the results are to be used for other than investigative support, then a panel of experts should be convened to assess the utility of the method and to define the limits of interpretation and conclusions drawn.

8.1.3 Internal validation should be performed and documented by the laboratory.

Validation

- Developmental validation is the acquisition of test data and determination of conditions and limitations. Developmental validation should be appropriately documented and should address specificity, sensitivity, reproducibility, bias, precision, false-positives, false-negatives, and determine appropriate controls. Any reference database used should be documented.

- Internal validation is an accumulation of test data within the laboratory to demonstrate that established methods perform as expected

Validation

- Internal validation should be performed and documented by the laboratory.
  - The procedure should be tested using known samples. The laboratory should monitor and document the reproducibility and precision and define reportable ranges of the procedure using control(s).
  - Before the introduction of a new procedure into sample analysis, the analyst or examination team should successfully complete a qualifying test for that procedure.
  - Material modifications made to analytical procedures should be documented and subjected to validation testing commensurate with the modification and have documented approval.

Validation

- Preliminary validation is the acquisition of limited test data to enable an evaluation of a method used to provide investigative support to investigate a biocrime or bioterrorism event. If the results are to be used for other than investigative support, then a panel of peer experts, external to the laboratory, should be convened to assess the utility of the method and to define the limits of interpretation and conclusions drawn.

- SOPs are for routine work
- But so locked in – restricts analytical thinking and possibly ignores both inculpatory and exculpatory evidence

Example Validation Criteria List

- Sensitivity
- Specificity
- Reproducibility
- Precision
- Accuracy
- Resolution
- Reliability
- Robustness
- Specified samples
- Purity
- Input values
- Quantitation
- Dynamic range
- Limit of detection
- Controls
- Window of performance for operational steps of assay
- Critical equipment calibration
- Critical reagents
- Databases

Note: Not all these need apply and others may be necessary

Interpretation

- To be reliable the validation data must be reviewed and interpretation guidelines must be based on the results

Validation

- The data, summary and documented approval of all validation conducted by the laboratory must be available for review

Errors and Bias

- We all can appreciate that a technique can be reliable despite the unavoidable prospect of *some* erroneous interpretation due to analyst error or bias
- Important to recognize that errors occur (human beings)
- What is done about the error is the real issue!
- Do not be distracted by a few rogue practitioners – focus on the stated practices for a discipline as the model

Errors

- Same issues raised for DNA
- NRC II Report (1996) addresses topic well

Errors

- Errors do occur in any endeavor involving humans
- Need to define the types of error that can occur
- Define those of consequence and which ones are not
- Most errors do not impact on the match/exclusion interpretation
- Those of consequence tend to result in false exclusions, not false inclusions
- One does want to know if an error has occurred in a case analysis that results in a false match or inclusion, a wrongful exclusion, or overstates the evidence
- Proper to ask if analyst has ever committed an error or errors and what was done about the error

Errors

- Instead some focus on diminishing the weight of evidence based on a hypothetical error rate that does not apply to the case at hand
- One might proffer “the fact that an error is possible necessarily lessens the value of the evidence”; However…
- A known error rate or proficiency test mistake is at best some indirect measure of the verity of the proposed results in any given case
- But can never be a direct measure of the reliability of the specific result(s) in question

Errors

- Error rates are difficult to calculate - they are fluid
- When an error of consequence occurs, corrective action is taken (to include review of cases analyzed by the examiner prior to and post the discovery of the error)
- That performance error may no longer impact negatively on the individual's future performance
- In fact, he/she may be better educated and less likely to err
- The calculation of a current error rate would have to accommodate corrective action
- The error should not be ignored and can be raised in court

Errors

- Most of the forensic disciplines employ non-consumptive forms of examination
- The most direct way to measure the truth of the purported results is to have another expert conduct his/her own review and/or
- Conduct a re-analysis (or review) (NRC II Report – DNA)***
- More meaningful and less costly than entertaining experts espousing hypothetical error rates
- Scientists should search for the truth

Errors

- An incorrect description of current error rates
- The false positive error rate for microscopic hair comparison is 12% based on a study of morphological hair comparisons and mitochondrial DNA analysis by Houck and Budowle
- The Houck and Budowle study contains no data on false positive errors
- Instead, it is a comparative study of the different resolving capacities of the methods
- Do not confuse these two issues!
- However, if an analyst purports that the hair (based on microscopic comparison) is from one person only (source attribution), then…

Do we need to improve the standard of forensic science?

The three A's

Absolutely

Always

Address best practices

Forensic Science Disciplines

- Many examples of the various techniques providing reliable results
- However, the 21st century scientist is better educated and more informed
- Foster questioning foundations – need to overcome culture and environment
- Higher standards of performance and expectations
- Need to move towards assuring that all practitioners perform at an acceptable minimum level
- Are training and quality assurance at an acceptable level, for example, in non-laboratory latent print examination settings?

Some might espouse "Microscopic Hair Comparisons Alone Should be Deemed Inconclusive"

- There may be a bias by some that the methodology is a prosecution tool only
- Consider two suspects and hair evidence is discovered
- Excludes suspect 1; fails to exclude suspect 2 and no mtDNA result
- Suspect 1 strategy may want to convey that suspect 2 could be the source
- Suspect 2 will want to question the reliability
- As long as done properly and given appropriate significance…..

Bias in Ascertainment

- Hypothesis supporting is different than bias
- If evidence excludes, most of the time suspect is excluded (not in court)
- If evidence fails to exclude, then results support prosecution
- Analyst could be objective, but in courtroom setting, one side's position is better supported
- Do not confuse this as advocacy

Bias

- Subjectivity exists in all disciplines, including DNA
- Subjectivity does not necessarily equate to unreliability
- Documentation and review (and/or re-testing) are best approaches to address potential bias and unreliability
- It is a form of peer review
- Being completely blind to information can lead to erroneous results, inefficiency, …
- Some examples are 1) time period between crime scene and shoe collection for wear (same for hair comparison) 2) husband and wife scenarios 3) intimate samples and interpretation

Evaluation of Forensic Disciplines

- Criticisms – should arise from anyone
- But need to develop infrastructure to promote criticism – education of scientists, lawyers, judges, lay people
- Need to reduce “silly” or solely adversary based criticisms
- Extremely valuable to work in partnership - best qualified and knowledgeable are those that use it
- Make use of outside expertise – forensic, academia, industry, other government agencies (national/international)

Interpretation

- Failure to exclude (or “Match” or whatever term)
- Exclusion
- Inconclusive
  - A number of scenarios

Three General Classes of Interpretation

(all based on the attempt-to-exclude principle)

1. Inclusion :

   -- failure to exclude,
   -- the profiles are sufficiently similar that they can be considered as
   possibly arising from the same source,
   -- part of the pool of candidates

Scientific Foundations and Best Practice

Ex: Friction Ridge Analysis

- Non-Numeric versus Numeric Standard
- Sufficiency
- Simultaneous Prints (Clusters)***
- Error Rate
- Standardization
- Research / Validation
- Information Sharing

Research / Validation

Underway

Permanence (Persistence)
Uniqueness
Fast Capture Fingerprinting
Automated Palm Print System – Functionality, Performance and Accuracy
Survivability Rate of Latent Prints on Explosive Devices
Processing Contaminated Evidence
Hyperspectral Imaging of Latent Prints
Quality Metrics
Black Box***

Proposed

More on Permanence (Persistence)
Cluster (Simultaneous) Prints
Quantity of Features Necessary for Effecting an Identification
Performance
Exculpatory Value of Data
Data Collection/Collation

Fingerprint Sourcebook

- Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST)
  - Creation of a SourceBook to include chapters on major topics…

Comparison and Methodology
Documentation
Equipment
Quality Assurance
Legal Issues
Safety
Research

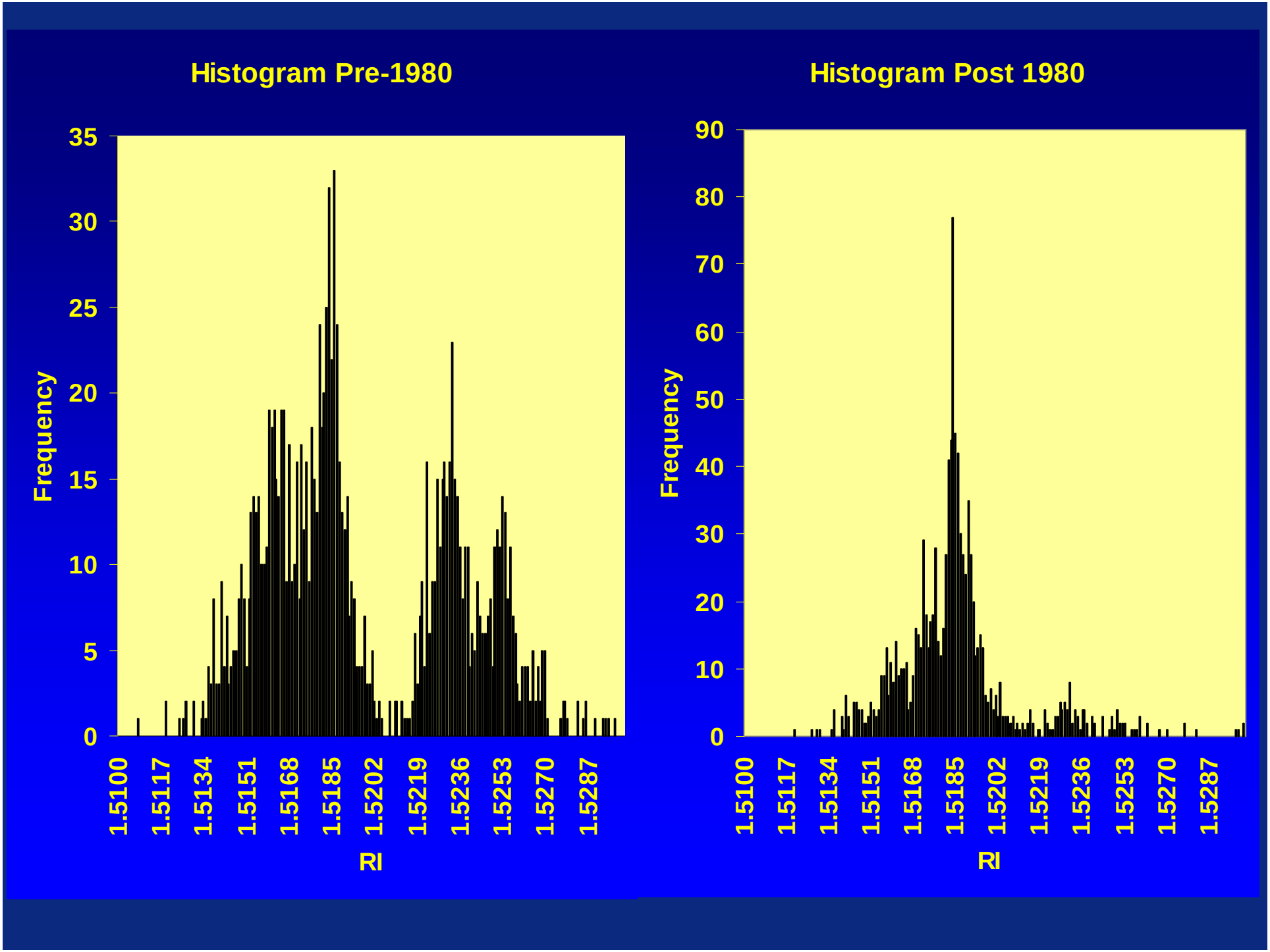
Background and History
Physiology and Morphology
Known Prints / Latent Prints
Classification
Automation
Processing
Preservation

Trace evidence interpretation

The population genetics conundrum

Temporal variability - distributions in the population change with time

- Products are used up / discarded/ removed from population
- New products enter population
- Manufacturer-controlled
- Usage / consumer driven


Histogram Pre-1980
Frequency
0
5
10
15
20
25
30
35
1.5100
1.5117
1.5134
1.5151
1.5168
1.5185
1.5202
1.5219
1.5236
1.5253
1.5270
1.5287
RI
Histogram Post 1980
Frequency
0
10
20
30
40
50
60
70
80
90
1.5100
1.5117
1.5134
1.5151
1.5168
1.5185
1.5202
1.5219
1.5236
1.5253
1.5270
1.5287
RI

Sampling Considerations
(crime scene)

- Data objectives
  - Develop a hypothesis
- More an experience and lessons learned approach
  - No two crime scenes are the same
- Plan

Sampling Approaches

- Logical and systematic
- Scheduled
- Risk-based
- Targeted***
- Statistical/Random

Other Sampling Considerations

- Number of samples
- Representative samples
- Sampling schemes
- Source heterogeneity
- Loss of information on sub-sampling

Example Publications

Budowle, B., Buscaglia, J., and Schwartz Perlman, R. Review of the scientific basis for friction ridge comparisons as a means of identification: Committee findings and recommendations. Forensic Science Communications 8(1),2006, at http://www.fbi.gov/hq/lab/fsc

Smrz, M.A., Burmeister, S.G., Einseln, A., Fisher, C.L., Fram, R., Stacey, R.B., Theisen, C.E., and Budowle, B. Review of FBI latent print unit processes and recommendations to improve practices and quality. J. Forens. Ident. 56(3):402-434, 2006

What is Statistics?

- A way to quantify or describe results
- What data are appropriate
- Quantity needed (sampling)
- Efficient experimental design
- Best ways to organize data
- Assist reasoning
  - controls, precision, confidence levels

Bumble Bee Analogy

It was determined that it was aerodynamically impossible for the bumble bee to fly

1. Either the bumble bee is too stupid and doesn't know it can't fly

2. Or the mathematical or statistical model is wrong

Bumble Bee Analogy

It is important to go out
in the field and
observe the Bumble Bee

1. Either the bumble bee is too stupid and doesn't know it can't fly

2. Or the mathematical or statistical model is wrong

Snedecor and Cochran (1967) state in their college-level statistics book (page 28):

"A test of significance is sometimes thought to be an automatic rule for making a decision either to 'accept' or 'reject' a null hypothesis."

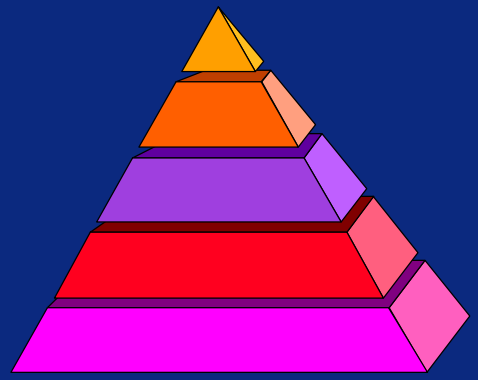
Snedecor and Cochran (1967) state in their college-level statistics book (page 28):

"This attitude should be avoided. An investigator rarely rests his decisions wholly on a test of significance. To the evidence of the test he adds knowledge accumulated from his own past work and from the work of others."

Models

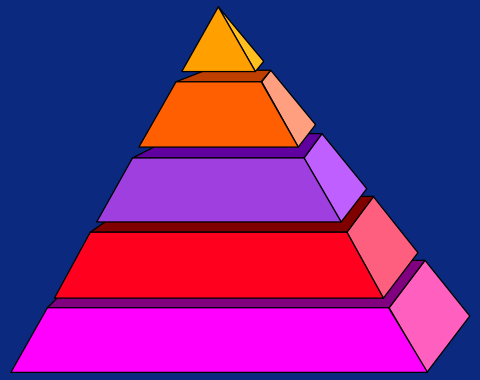
- Simplification or substitute of what is to be studied
- Assumptions are made (and need to be stated)
- Incomplete by definition
  - still useful – but beware of those who use models as absolutes
  - Can be useful for improvement

USDA Food Pyramid (Physical) Model



- Condenses hundreds of research papers
- Simplifies
- Inevitable loss of information
- Valuable for communication

Latent Print Models



- Do not use all data
- Simplify even level 1 and 2 data
- Inevitable loss of information
- So models do not provide values for all that may be seen by analyst

Bayesian Statistics

- We are all Bayesians
- Bayesian approach is suggested as a good model for how we should think about evidence
- BUT – it is often not possible to accurately calculate for even the simplest cases
- Mandates going beyond role of the scientist
- Usurps authority of fact finder who determines guilt or innocence

Recommendations
(no specific order)

- Continuous improvement of forensic science is as much a management challenge as it is a technical one
- Technical Leader concept
- Qualifications (education and experience) and training (science, best practices and ethics)
- Analytical education/training
- Statistics – might consider experimental/systems design for technical leader
- Nationally coordinated systems are a proven approach for national standards

Recommendations

- Support SWGs for more than just meeting and preparing documents on QA – need to carry out research initiatives
- Develop validation criteria list for each discipline
- Develop research needs list (see Budowle et al and friction ridge analysis as example)
- Develop sourcebooks – include reference material
- Develop strategic plan(s) for discipline specific research needs
- Develop better (collaborative) research initiatives
- Publish above – at the least in Forensic Science Communications

Recommendations

- Recognize that current culture is detrimental – advocate for example that errors should not be considered negatively – unless not addressed
- Re-testing and/or review are best approaches for addressing errors and bias
- Population genetics approaches for other disciplines may not be appropriate
- When using a number of characters to resolve source, studies to determine dependence are needed
- Legislation – QA standards (not standardization) – enforcement mechanism***
- More training on sampling strategies
- Ethics training
- Verification, Blind verification

Recommendations

- Each discipline has its own requirements
- Create the right environment and science issues will be addressed professionally and responsibly
- Infrastructure enhancement