Forensic Science Applied to CBRNE Evidence and Events

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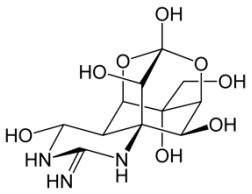
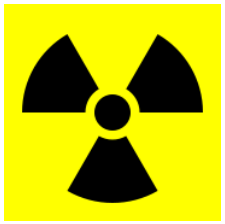
Important to Consider

•It will be most helpful for you to understand something about the science, applications and issues to ensure that the most appropriate laws and policies are implemented.
•While there are some similarities and overlaps with the issues and concerns that you have heard about thus far, there are also some significant differences.
•Often, with CBRNE evidence and associated forensic analyses, interpretation and reporting, there are additional stakeholders involved. These are not the same as those my colleagues have been addressing or implying.
•Every forensic scientist is not expert in these areas, it requires specialized expertise, technology and facilities. Similarly, most experts in CBRNE are not experts in the forensic issues.



Terms of Reference: “CBRNE”

- C = Chemical Weapons and Hazards (including Military CW; Synthesized Poisons; Commercially Available, Toxic Industrial Chemicals, Biotoxins)
- B = Biological Weapons, Infectious Diseases and Biotoxins (Human, Zoonotic, Animal, Disease, Naturally Produced Toxins)
- R = Radiological Materials (Medical and Commercial Use), Radiological Dispersal Devices
- N = Nuclear Materials, particularly Special Nuclear Materials (SNM. Aka Fissile Materials); Nuclear Weapons
- E = Explosives (“Homemade”, Military, Commercial, Industrial; and Associated Devices)

Forensic Exploitation of CBRNE Evidence

- Information of forensic value can be obtained from the source material itself
- What was done to some CBRNE materials for nefarious use ("weaponization") can provide information of forensic value (e.g., biological agents)
- Construction or configuration of the device, delivery system or method of dissemination can provide information of considerable forensic value
- Methods, tools, equipment, sources used and associated traditional forensic evidence can be of considerable value
- Close collaboration with experts in
  weapons phenomena and effects (including
  medicine/health for chem/bio/rad)

“Forensics” and “Attribution”

- **Forensics**: Analysis and interpretation of physical evidence to determine relevance to events, people, places, tools, methods, processes, intentions, plans
  - *Identification and Characterization*
  - *Inclusion toward Attribution or Exclusion*
- **Scientific Attribution**: Assignment of a ***sample of questioned origin*** to ***a source of known origin*** to a ***high degree of scientific certainty*** (at the same time excluding origination from other sources)
  - attribution requires comparison of “Q” with “K”
  - Increasingly and more intensely, the science underlying “attribution” is being scrutinized, expectations are increasing for accuracy, reliability, repeatability, validity
- **Legal & Policy Attribution:** Who did it or is culpable (to acceptable legal burden of proof or undefined policy standards)

Chemical Weapons/Hazards: Forensic Analysis

- Examples
  - Military: Nerve Agents--Sarin ("GB"), Soman ("GD"), Tabun ("GA"), "VX"; Blood Agents—Several Cyanide Compounds (also Toxic Industrial Chemicals); Blister Agents—Lewisite, Sulfur Mustard; Choking/Pulmonary—Phosgene, Ammonia, Chlorine, Bromine (also Toxic Industrial Chemicals)
  - Toxic Industrial Chemicals-- See above, and Other--Certain Pesticides, Ethylene Glycol
  - Other: Fentanyls (opioids)
  - Biotoxins: Abrin (Rosary Pea), Ricin (Castor Bean); Saxitoxin (marine organisms); Strychnine (*Strychnos spp.),* Tetrodotoxin (Puffer Fish)

- Examples of Nefarious Use
  - Aerosolization for Effects on Targeted or Large Populations (Agent Dependent)
  - Targeted Poisonings
  - Disruption or Damage to Commercial Vehicles Carrying Large Quantities or Production Facilities Resulting in Release and Exposure

- Forensic Exploitation
  - Identification of toxic substance
  - Identify possible sources or production methods
  - Packaging, delivery device, dissemination, release methods/equipment; including associated "biometric"/impression and trace evidence
  - Method/Technique for Damaging Vessel or Facility
  - Medical Presentation and Effects

Biological Agents and Toxins

- Examples of Agents/Toxins
  - Bacillus anthracis (“anthrax”)
  - Francisella tularensis (“tularemia”)
  - Salmonella spp./Shigella spp (food borne pathogens)
  - Coxiella burnetii (“Q fever”)
  - Foot and Mouth Disease Virus (FMD) (animal pathogen)
  - Puccinia graminis Ug99 (wheat rust)
  - Botulinum toxin (Botox)
  - Ricin (from Castor Bean)
- Examples of Nefarious Use
  - 2001 Anthrax Attacks
  - Dissemination in public place
  - Contamination of food source (1984 Rajneeshee, Oregon)
  - Localized Aerosol Dissemination
  - Attack against US beef or swine industry
  - Attack against US wheat crop
  - Focused attack, specific targets, small quantities
  - Targeted or Mass Poisoning

Forensic Analyses Focused on Phylogenetics, Genomics, Physical-Chemical (Weaponization), Disease Presentation, Dissemination Method

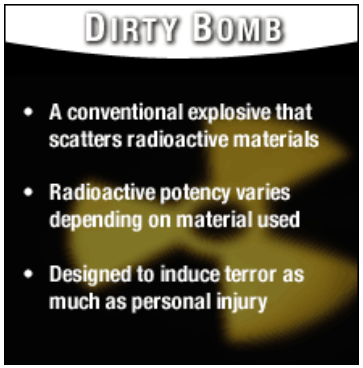
Each Scenario Could Provide Significant Science Challenges

See: “Review of the Science Used by the FBI in the Anthrax Mailing Attacks, NRC 2011

“Microbial Forensics”, 2nd Ed. Elsevier 2011

Radiological Dispersal Device, aka "Dirty Bomb"

- Examples of Materials
  - Millions of legitimate sources worldwide (industry, medicine, research); Black market worldwide
  - Isotopes deemed likely for use in RDD, produced by reactors
    - Americium-241
    - Californium-252
    - **Cesium-137**
    - **Cobalt-60**
    - Iridium-192
    - Plutonium-238
    - ***Polonium-210******
    - Radium-226
    - **Strontium-90**



Forensic Analysis: Source Materials And Device (as with an IED)

- How Selected and Used by Adversary
  - Dispersion of ionizing radiation using explosive force of IED
    - alpha particles
    - beta particles
    - gamma rays
    - x-rays
  - Medical and health effects dependent on presentation
    - Skin Contact
    - Inhalation
    - Intake via Food/Water

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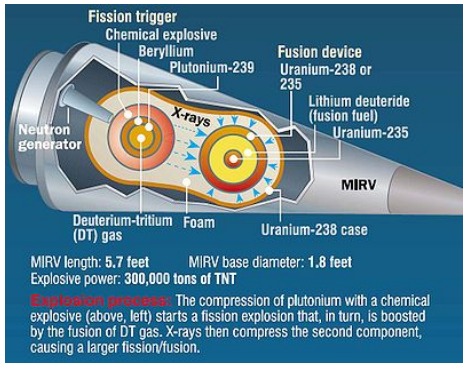
Nuclear Materials and Weapons

"Pre-Det" and "Post-Det" Forensic Exploitation

- Nuclear Weapon
  - Diverted or stolen weapon from declared or undeclared nuclear weapon state, particularly those with poor security in nuclear weapons complex (materials inventory accountability, expertise, weapons inventory); Provided weapon from rogue state
  - Usually constructed with Uranium and/or Plutonium isotopes (Special Nuclear Materials, "fissile materials")
  - Requires special technical capabilities and know-how, many levels from device construction, radio-chemistry, weapons phenomena and effects



- Improvised Nuclear Device, Example
  - Two pieces of fissionable material, one at either end of tube ("barrel")
  - Each piece is sub-critical (mass required for detonation)
  - HE used to blow one piece into the other to achieve criticality
  - Practical with only enriched ^{235}U
  - Forensic exploitation: Pre-blast-Device and Materials; Post-Blast: Residues, Phenomena and Effects

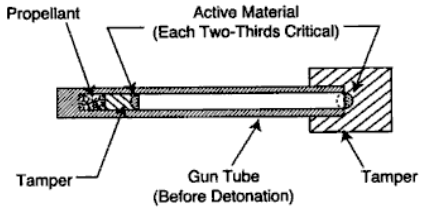
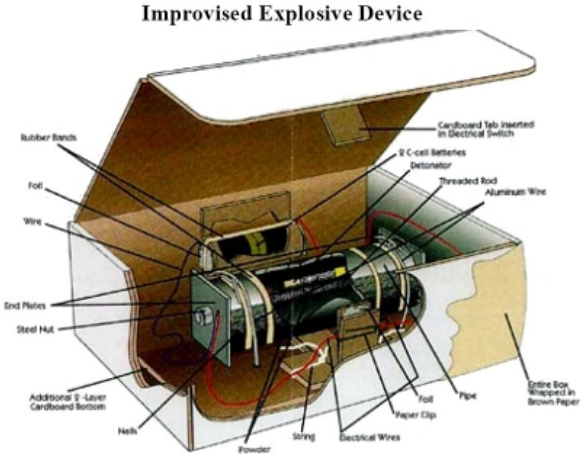


Figure 2-VII. Gun Assembly Principle

See: "Nuclear Forensics: A Capability at Risk; NRC 2010
"Nuclear Forensics": Role, State of the Art, Program Needs; APS-AAAS 2010

Forensic Analysis: Explosives, Ordnance and Improvised Explosive Devices

- Chemical Analysis of Main Charge (Explosive Material) and Determination of Possible Sources
- Identification of Components/Manufacturers and Possible Sources (e.g., Timing and Fuzing)
- Exploitation of Electronic/Communication Components
- Materials Analysis of Components of Most Probative Value
- Construction/Configuration of Device ("Bombmaker's Signature")
- Packaging
- Associated Evidence: e.g., Fingerprints, Trace Evidence, Internal/External Markings, Toolmarks, Binding/Wrapping Materials



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Uses of Forensic Results and Interpretations from CBRNE Evidence

- Criminal Investigations
- Civil Investigations
- Jurisprudence & Litigation
- **Intelligence/Counter-terrorism**
- **Non-Proliferation/Counter-proliferation**
- **Operational Decision Making**
- **Policy Decisions**

- **Did A Crime/Event or Activity of Interest) Occur?**
- **What Happened?**
- **How Did It Occur?**
- **When Did It Occur?**
- **Where Did It Occur?**
- **Why Did It Occur?**
- **Who Was Involved?**
- **What Evidence Exists? What Does It Tell Us? How Strong are the Links?**
- **How Reliable and Credible is the Evidence?**
- **What Alternative Explanations are There for the Evidence?**
- **Can We Defend Our Conclusions and Actions?**

Forensic Investigation Can Generate Leads, Shape Investigations/Intelligence Gathering and Inform Answers

Science Alone Does Not Determine Outcome

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Lead U.S. CBRNE Forensic Investigation and Analysis Capabilities

- Chemical Weapons Forensics: Department of Defense, FBI, Department of Energy National Labs, Specialized Contractors
  - Does not include forensic toxicology, drug, routine poisons (Crime & ME Labs)
- Microbial (BW) Forensics: FBI, Department of Homeland Security/NBACC, Certain Universities, Department of Energy National Labs, Other Federal Agencies, Specialized Contractors
- Radiological Forensics: Department of Energy National Labs, Department of Defense, FBI
- Nuclear Forensics: Department of Energy National Labs, FBI, Department of Defense
- Explosives (Including Residues)/IED Forensics: FBI, BATF (IEDs, bulk/residue chemistry, including high explosives), Department of Defense (ordnance, IEDs), Some State/Local Labs (small, unsophisticated devices; routine explosive residues)

CBRNE Forensic Science Also Pursues Quality and Timely Science

- Appropriately educated and credentialed scientists
- Laboratories that achieve or mirror accreditation, GLP
- Rigorous, accepted and peer-reviewed scientific methods
- Science that informs answers to investigative, legal, intelligence, operational and policy questions

Policy Issues:
Does the science meet above expectations of different sets stakeholders on a timely basis?
What are the gaps?
And can they be effectively addressed?
How and how much is required?

- Goals for the Science
  - Robust Collection & Preservation of Evidence
  - Relevant Exploitation of Sample
  - High Discrimination
  - Enables Comparison of K and Q Samples
  - Utility Across Known, Encountered Sample Types
  - Accuracy
  - Reliability
  - Defined & Acceptable Error Rate
  - Speed & Responsiveness
  - Repeatability
  - Transferability
  - Validity Can Be Independently Established
  - Results Probative, Interpretable, Explainable, Defensible

Examples of "Grand Challenges" with CBRNE Forensic Science

- Chem:
  - Limitations to source attribution due to nature of materials
  - Highly toxic; Contamination of objects/substrates with traditional probative forensic evidence
- Bio:
  - Discerning natural, deliberate and accidental events when diseases present similarly
  - Determining information of forensic value in biologically complex samples
  - Substantial unknowns with respect to microbes and behavior in environment
  - Understanding the limits of science and technology and source attribution
- "Rad", RDD
  - Known limitations forensic analysis of pattern/impression evidence associated with dispersal device (fingerprints, toolmarks et al)
  - Limitations to determining origin of source materials
- Nuclear
  - Classified nature of weaponry and some key knowledge
  - Access to sensitive/classified databases necessary for effective comparative purposes
- Explosives/IEDs
  - Known limitations forensic analysis of pattern/impression evidence associated with dispersal device (fingerprints, toolmarks et al); materials analysis of components
  - Limits to what instrumental analysis of materials can provide vis-à-vis source attribution, depending on materials used

Examples: Big Policy Issues for CBRNE Forensic Science

- Defining how much, what kind and what quality of scientific evidence is required to inform a policy decision (to take action against a state or sub-state group)
- No standards for interpreting and communicating CBRN forensic evidence to different stakeholders
- How much investment is required for personnel, infrastructure and equipment for specialized capabilities (low frequency-high consequence activities and events)
- How best to mirror end-to-end forensic quality requirements/expectations in some areas within sequestered, specialized laboratories
- Prioritizing and coordinating investments in the USG in Research, Development, Testing, Evaluation & Validation for stronger scientific basis for certain disciplines
- Scientific “Grand Challenges” in Some Fields

American Chemical Society
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Forensics: Science Policies to Increase Confidence

September 26, 2012, 12:00 – 1:30 p.m., SVC 200/201

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