Forensic Fire Death Investigation Course Syllabus
40 hour course

Monday

<u>Welcome and Orientation (0800-0830) Mr. John Madden/Staff</u>

Welcome and Orientation to The FFDIC

I. Introduction of John Madden
II. Introduction of the County Sheriff
III. Introduce each member of the Staff
IV. Thank the students for coming
  A. Announcements
  B. Brief overview of Classroom and Field Ops
  C. Late breaking changes to Schedule and Protocol

<u>Class Expectations (0830-0900) Mr. Kevin McBride</u>

Class Expectations
SLOFIST Harassment Policy
Kevin McBride

I. This policy is intended to prevent any participant in SLOFIST operations from being subjected to discrimination or sexual harassment. SLOFIST Policy essentially mirrors that of the Arroyo Grande Police Department as set out in The Arroyo Grande Police Department Policy Manual Section 14C.
  A. SLOFIST maintains a work environment that is free of all forms of discriminatory harassment, including sexual harassment and retaliation.
  B. SLOFIST prohibits all forms of discrimination, including any employment-related action by an employee that adversely affects an applicant or employee and is based on race, color, religion, sex, age, national origin or ancestry, genetic information, disability, military service, sexual orientation and o her classifications protected by law.
  C. Conduct that may under certain circumstances, constitute discriminatory harassment, can include making derogatory comments, crude and offensive statements or remarks, making slurs or off-color jokes, stereotyping, engaging in threatening acts, making indecent gestures, pictures, cartoons, posters or material, or making inappropriate physical contact.

D. SLOFIST prohibits all forms of discrimination and discriminatory harassment, including t. It is unlawful to harass an applicant or a staff member because of that person's sex.

1. Sexual harassment includes, but is not limited to, unwelcome sexual advances, requests for sexual favors or other verbal, visual or physical conduct of a sexual nature under any circumstances or for any reason
2. In particular, this includes conduct that has the purpose or effect of substantially interfering with a member's work performance or creating an intimidating, hostile, or offensive work environment.

II. For further clarification of any of these policies see The Arroyo Grande Police Department Policy Manual Section 14C

<u>Fundamentals of Fire Behavior/Investigations (0900-1100) Mr. Brian Parker</u>

Fundamentals of Fire Behavior/Investigations
Introduction to Origin and Cause Investigation
ATF CFI Brian Parker

I. Basic Fire Behavior
   A. What is Fire (NFPA 921:3.3.62)
      1. A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities.
      2. $C + O_2 \rightarrow CO_2$
      3. $2H_2 + O_2 \rightarrow H_2O$
   B. Fire Triangle
      1. Oxygen
      2. Fuel
      3. Heat
   C. Fire Tetrahedron
      1. Oxygen Heat and fuel
      2. Uninhibited Self-sustaining Chain Reaction
   D. What is heat?
      1. Heat is not the same as temperature
      2. Heat is a form of energy that results from the random motion of molecules
      3. It is the amount of energy required to maintain or change the temperature of an object
   E. What is heat transfer?
      1. Energy that is transferred between objects due to a temperature difference
      2. Heat is always transferred from hotter objects to colder objects
   F. NFPA 1033
      1. NFPA 1033: 1.3.7 The fire investigator shall have and maintain at a minimum an up-to-date knowledge of the following topics beyond the high school level:
         a. Fire Science
         b. Fire Chemistry
         c. Thermodynamics
         d. Thermometry
         e. Fire Dynamics
         f. Explosion Dynamics
         g. Computer fire modeling
         h. Fire Investigations
         i. Fire Analysis (New in the 2014 edition)
         j. Fire Investigation Methodology
         k. Fire Investigation Technology
         l. Hazardous Materials
         m. Failure analysis and analytical tools
         n. Fire Protection Systems

        o. Evidence documentation, collection and preservation
        p. Electricity and electrical systems
        2. NFPA 1033: 1.3.8 The fire investigator shall remain current in the topics listed in 1.3.7 by attending formal education courses, workshops, and seminars and/or through professional publications and journals.

G. Thermometry: science of measuring the temperature of a system or the ability of a system to transfer heat to another system.

H. Heat/Energy Transfer
    1. Kinds of transfer
        a. Conduction
        b. Convection
        c. Radiation
    2. Conduction (NFPA 921:3.3.37) Transfer of heat energy through a material or to another material by direct contact of molecules the effect is most noticeable in solids.
        a. Steady heat flow through a solid
        b. Conduction and heat vs humans
            i. 212°F for 2 sec = full thickness burn
            ii. Conductive burns form metal objects will often transfer the pattern of the object to the skin
    3. Convection (NFPA 921:3.3.37) Heat transfer by circulation within a medium such as a gas or a liquid.
        a. Types of convection
            i. Natural (free) Convection –buoyancy induced flow is caused by density (air temperature) difference
            ii. Forced Convection –flow induced by external source
        b. Convection heat vs humans
            i. 360°F for 30 sec = irreversible skin burns
    4. Radiation (NFPA 921.3.3.142) heat transfer by way of electromagnetic energy
        a. Radiation heat vs humans
            i. 1 kW/ m2 Sunshine = some pain to bare skin
            ii. 4 kW/m2 for 30 seconds = blisters to bare skin
            iii. 20 kW/m2 for 5 seconds = burns to bare skin
    5. Compartment Fire example
        a. Convection- heat rising from fire in heated air
        b. Radiation- heat directly warming surfaces lateral to the fire
        c. Conduction- fire distributing heat to contacted surfaces
            i. Vapor ignition

I. Types of combustion
    1. Kinds
        a. Spontaneous
        b. Smoldering
        c. Pre-mixed
        d. Diffusion

2. Spontaneous Ignition (NFPA 921:3.3.169): Initiation of combustion of a material by an internal chemical or biological reaction that has produced sufficient heat to ignite the material
3. Smoldering (NFPA 921:3.3.161) Combustion without flame, usually with incandescence and smoke
4. Pre mixed flame (NFPA 921:3.3.133)
    a. Any flame in which the fuel and oxidizer are initially mixed and ignited.
    5. Diffusion flame (NFPA 921:3.3.47) A flame in which fuel and air mix or diffuse together at the region of combustion
    a. Fick's Law of Diffusion– The movement of molecules from an area of high concentration to an area of low concentration
    b. Cross section of a candle
        i. Light zone
        ii. Flame zone
    c. Diffusion flames can have different appearances

J. Types of fuels
1. What is burning?
    a. Solids
    b. Gasses
    c. Liquids
2. Solid fuels
    a. Solid fuels must be heated until they begin to decompose and gasify, the gas is what ignites and burns.
    b. This process is referred to as pyrolysis.
    c. Pyrolysis (NFPA 921:3.3.139) A process in which material is decomposed, or broken down, into simpler molecular compounds by the effects of heat alone; pyrolysis often precedes combustion.
    d. Char or charring
        i. Carbonaceous material that has been burned or pyrolyzed and has a blackened appearance.
        ii. Bottom Line: Pyrolysis is the process, charring, or some kind of physical change, is the result.
3. Liquid fuels
    a. Liquid fuels must produce vapors to burn, the vapor is what ignites and burns. Some liquid fuels must be heated to vaporize, while others vaporize at normal atmospheric temperatures.
    b. Flash point of a liquid (NFPA 921:3:3:82) The lowest temperature of a liquid, as determined by specific laboratory tests, at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface
        i. Gasoline = -450°F
        ii. Methanol = 540°F
        iii. Kerosene = 1100°F
    c. Classification of liquid fuels
        i. Flammable liquids have a flash point of less than 1000°F

ii. Combustible liquids have a flash point of 1000°F or greater
iii. Use the term IGNITABLE LIQUID. It encompasses both classes of fuels

4. Gaseous fuels
   a. Already in a proper state to be ignited
   b. Common gasses include methane butane propane acetylene and hydrogen COMMON
   c. Flammable limits (NFPA 921:3.3.78)
      i. The upper or lower concentration limit at a specified temperature and pressure of a flammable gas or vapor of an ignitable liquid and air, expressed as a percentage of fuel by volume that can be ignited.
      ii. Upper concentration = UEL
      iii. Lower concentration = LEL
   d. The flammable limits are expressed as a percentage of the fuel gas or fuel vapor content in the air.
      i. Natural gas 4.5% to 15%
      ii. Acetylene 2% to 100%
      iii. Propane 2.15% to 9.6%
      iv. Gasoline 1.4% to 7.6%
   e. Specific gravity (Vapor Density) (NFPA 921:3.3.165) The ratio of the average molecular weight of a gas or vapor to the average molecule weight of air.
      i. Vapor densities of common fuels

Fuel	Vapor Density
Hydrogen	0.07
Methane	0.55
Acetylene	0.90
Carbon Monoxide	0.97
Ethane	1.03
Propane	1.51
Butane	1.93
Acetone	2.00
Pentane	2.50
Hexane	3.00
Gasoline	>1.00

H. Fire growth and behavior
    1. Phases of fire
        a. Ignition phase
        b. Growth phase
        c. Fully developed
        d. Decay phase
    2. Transition to fully developed (NFPA 921:3.3.83)
        a. Flashover (NEPA 921:3:3:83)
        b. A transition phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space, resulting in full room involvement or total involvement of the compartment or enclosed space.
        c. "When a fire in a room becomes a room on fire"
        d. -Slide sequence of two rooms on fire-

II. Fire scene investigation
    A. Scene investigation- why?
        1. The need to bring the scene to the courtroom
        2. Never miss an opportunity to walk where the bad guy walked
        3. The scene is a polygraph
    B. The "Scientific" method-A Systematic Approach (NFPA 921:4.3)
        1. Recognize the need
        2. Define the problem
        3. Collect the data
        4. Analyze the data
        5. Develop the hypotheses
        6. Test hypotheses
        7. Select final hypothesis
        8. Make a determination
    C. Exterior scene Investigation
        1. Arrival at scene
        2. Security and safety at the fire scene
        3. Interview witnesses, firefighters and cops
        4. Size up needs assessments
        5. Photograph the exterior
        6. Document fire patterns and areas of damage
        7. Document electrical and fuel gas services
        8. Decon: soap, water, nylon brush
    D. Interior examination
        1. Fire patters/heat indicators
        2. Inventory
        3. Contents
        4. Appliances
        5. Fire protection systems (alarm/sprinkler)
        6. Remains of devices and containers
        7. Least to most burnt

E. Fire patterns
  1. Artifacts left by the fire
  2. Fingerprints of the fire
  3. Noted and documented
  4. Part of data collection process
  5. Patterns
    a. "V" pattern
    b. Exterior"V" pattern
    c. Lines of demarcation
    d. Degree of char/consumption
    e. Heat vs. concrete surfaces- Spalling
    f. Heat vs. drywall surfaces- Clean Burn
    g. Heat vs metals
      i. Structural steel fails above 1000°F
      ii. Aluminum melts at 1220°F
      iii. Copper melts at 1981°F
    h. Average turbulent flame = 1500 -1800°F
    i. Pour patterns of ignitable fluids
    j. Inventory and furnishings

F. Fire protection systems
  1. Cause determinations
    a. Accidental
    b. Incendiary
    c. Undetermined
    d. Natural
    e. Suspicious (should not be used)
  2. Accidental (NFPA 921:20.1.1) The proven cause does not involve an intentional human act to ignite or spread fire into and area where the fire should not be
    a. Accidental causes
      i. Electrical
      ii. Heating equipment
      iii. Mechanical
      iv. Cooking
      v. Smoking
      vi. Candles
      vii. Spontaneous heating
      viii. Children
  3. Incendiary (NFPA 921:20.1.3) - An incendiary fire is a fire that is deliberately set with the intent to cause a fire to occur in an area where the fire should not be
    a. Incendiary Fire Indicators - NFPA 921 24.2
      i. Multiple Fires
      ii. Trailers
      iii. Lack of Expected Fuel Load or Ignition Sources
      iv. Exotic Accelerants

        v. Unusual Fuel Load or Configuration
        vi. Burn Injuries
        vii. Incendiary device, delay device or Ignitable Liquid
    b. Assessment of Fire Growth and Fire Damage
    c. Potential Indicators Not Directly Related to Combustion
        i. Remote Locations with View Blocked/Obscured
        ii. Fires near Service Equipment and Appliances
        iii. Removal or Replacement of Contents Prior to Fire
        iv. Entry Blocked or Obstructed
        v. Sabotage to the Structure/Fire Protection System
        vi. Open Windows and Exterior Doors
4. Undetermined (NFPA 921:20.1.4) Whenever the cause cannot be proven to an acceptable level of certainly

What Kills People in Fires (1100-1200) Dr. John DeHaan

What Kills People in Fires?

John D. DeHaan, Ph.D.
Fire-Ex Forensics, Inc.

I. Introduction
   A. What killed the victim?
   B. What caused the fire?
   C. How did these two events interact?
   D. Pitfalls
      1. Prejudging events – accident or intentional
      2. Premature removal of body
II. Effects on People
   A. What kills people in fires?
      1. Heat
      2. Hot Gases
      3. Flames (Incineration)
      4. Smoke
      5. Carbon Monoxide
      6. Anoxia
      7. Blunt Trauma
   B. Tenability
      1. Definition – The ability of humans to escape a fire is measured by the time frame for which their environment remains survivable.
      2. Considerations – All the following can contribute to death:
         a. Heat transfer
         b. Hot toxic gases
         c. Carbon monoxide
         d. Anoxia/Hypoxia
         e. Flames
         f. Blunt trauma
         g. Visibility
   C. Smoke
      1. What is it?
         a. Hot gases
         b. Carbon monoxide
         c. Other toxic gases/aerosols
         d. Soot
         e. Hypoxia – low oxygen
         f. Visibility impaired
      2. Hot Gases
         a. Inhalation of hot gases causes

        i. Edema (swelling and inflammation) of mucosal tissues
        ii. Can cause vagal inhibition
        iii. Laryngeal spasms (?)
    b. Rapid cooling by evaporation from mucosal tissues limits damage to trachea unless water saturated (steam)
    c. Usually hot enough to burn facial hair and skin if inhalation is fatal
3. Smoke also contains:
    a. Soot
        i. Hot particles that cause burns and edema in respiratory system
        ii. Toxic chemicals – ingestion or inhalation
        iii. Asphyxiation – blockage of airways
        iv. Obscures vision – escape path
    b. Toxic gases and aerosols
        i. Acidic – HCl, H_2SO_3
        ii. Toxic – HCN, free radicals
        iii. Irritants – Acrolein, HCl – coughing can incapacitate
4. Toxic gases
    a. Carbon monoxide
    b. Hydrogen cyanide (HCN)
    c. Predicting the time to incapacitation
        i. Carbon monoxide
        ii. Anoxia – Hypoxia
        iii. Hydrogen cyanide (HCN)
        iv. Carbon dioxide (CO_2)
5. Carbon monoxide
    a. In free-burning fires: CO in combustion products as low as 0.02% (200ppm)
    b. In smoldering, post-flashover or underventilated fires: CO concentration is 1 to 10%
    c. COHb complex is 200 times more stable than OHb
    d. Anesthetic/asphyxiant effect: not only replaces OHb, but kills or incapacitates cell functions.
        i. Particularly neurons and red muscle in the heart
    e. Everyone in good health has 0.5-1% COHb
    f. Smokers can have 4-10% COHb levels
    g. Accumulation:
        i. The Stewart Equation:
        ii. $COHb = (3.317\times10^{-5})(CO)^{1.036}(RMV)(t)$
        iii. Where:
            1. COHb = Carboxyhemoglobin in the blood (percent)
            2. CO = Level of carbon monoxide in the air (ppm)
            3. RMV = Respiration minute volume (L/min)
            4. t = Time of exposure (minutes)

h. General Effects (healthy victims)
   i. 20-30% satn: headache, dizziness
   ii. 30-40% satn: vomiting
   iii. 40-50% Unconsciousness
   iv. 50% or greater: death
i. Fatal at levels of 20% COHb in some victims
j. Other victims reach 90%
k. "50% level = Death" may mean that at 50% COHb, 50% of subjects are already dead
l. Variables: health, age, physical activity, other toxic materials, CO concentration in air
m. Turn off rates (half-life) of the removal from CO exposure
   i. 50% reduction in 250-320 minutes in air
   ii. 50% reduction in 65-85 minutes in O2
   iii. 50% reduction in 20 minutes in hyperbaric O2
n. Facts of CO exposure
   i. It must be inhaled
   ii. It is not absorbed passively by the body lying dead in a CO-rich environment
   iii. It is not lost from a dead body
   iv. It is very stable in post-mortem blood
   v. It is very difficult to measure in organs or tissue

6. Hydrogen Cyanide (HCN)
   a. Extremely toxic
      i. 170-230ppm = death in 30 min
      ii. 250-400ppm = death in 5 min (SFPE)
   b. Produced by any fuel that contains nitrogen:
      i. Hair
      ii. Wool
      iii. Fur
      iv. Leather
      v. Polyurethane
      vi. Nylon
   c. Absorbed through inhalation and ingestion
7. Anoxia/Hypoxia
   a. Anoxia = No oxygen
   b. Hypoxia = Lack of oxygen
      i. 15 to 21% - No effect
      ii. 10 to 15% - Disorientation, judgment affected
      iii. <10% - Unconscious and death
   c. Aggravated by high CO2 levels (which accelerate inhalation rates)
8. Smoke and Visibility
   a. Why do some escape? – Human factors, exposure conditions
   b. Optical density
   c. Walking speed – 2 m/s in clear, daylight conditions

d. Wayfinding – familiar with surroundings
e. Smoke production predictions – can be calculated from fuel properties and ventilation conditions
f. Smoke can be both disorienting and disabling = Incapacitation

D. Heat
1. Predicting time to incapacitation
2. Inhalation of hot gases (see II, C, #2 above)
3. Effects of heat and flame – radiant, conducted or convected heat or direct flame contact
4. Radiant heat flux > 2.5kW/m2 or Temperature > 250°F are considered untenable
5. Flames (incineration)
a. Skin has thermal inertia, and heat has to penetrate some distance
b. Radiant heat:
i. 2-4kW/m2 for 30 seconds produces pain
ii. 4-6kW/m2 for 8 seconds produces 2° burns
iii. 10kW/m2 for 5 seconds produces deeper injury
iv. 50kW/m2 produces 3° and 4° burns
c. Conducted heat:
i. 130°F – Skin cells damaged
d. Convected heat:
i. 130°F (54°C) Water at 150°F (65°C) can cause deep burns in seconds
6. Radiant Heat v. Time
a. Stoll & Greene, 1962

E. Blunt Trauma
1. Falls
2. Structural collapse
3. Explosions
4. Impact on stationary surfaces

III. The Fire Environment
A. Pathologists and homicide detectives must appreciate the fire environment – heat and its transfer, temperatures, flames, and smoke – and the distribution of fire products and the variables of human exposure to those conditions.
B. How was this person exposed to fire and its products?
C. What is the duration and intensity of the fire?
1. What is this person exposed to right now?
2. What if he/she moves?
3. What is the duration and intensity of this fire and where is the victim?
4. What is the duration and intensity of this post-flashover room fire?
5. What is the duration and intensity of this gasoline vapor explosion?

IV. What kills people in explosions?
A. The natures of sudden exposure to:
1. Hot gases
2. Flames (Incineration and thermal radiation)
3. Smoke

4. Carbon monoxide
5. Anoxia/hypoxia in combustion explosions
6. Blunt trauma
7. Blast pressure – internal injuries
8. Projectiles – fragments of device or nearby materials
9. Impact

B. A deflagration is of very short duration
   1. If you're inhaling during the flash, you can have these inhalation system injuries. If you don't inhale, there won't be thermal injuries.
   2. Deflagration produces very little soot, CO, or intermediate products (air/fuel well mixed with excess oxygen).
   3. Anoxia – Hypoxia
      a. In a closed room, there will be oxygen deprivation after a deflagration.
      b. Heat release curve (kW) for 2 liters of Coleman fuel (ignited at 30 seconds)
      c. CO2 and O2 CO
         i. Door open
         ii. Door closed
         iii. HRR of test fire
      d. Overlay of CO2, O2 and CO shows that CO onset is 30+ seconds behind other peaks
      e. Exposure at toxic levels (hypoxia, CO2 and CO) is very prolonged with door closed
   4. Radiant heat flux v. injury
      a. Minimum time for pain is about 2 seconds
      b. Minimum time for blisters is about 6 seconds
      c. Minimum heat flux for injury or pain is about 2kW/m2
   5. What type of fire was it and what was their exposure?
      a. Prolonged fire
      b. Post-flashover
      c. Flash fire or deflagration only?
         i. Duration of 1-3 seconds
         ii. Same heat flux, but very different exposure from post-flashover
   6. Where is the thermal injury or damage?
      a. Shoes, socks, cuffs melted or scorched?
      b. Lower legs burned?
      c. Probably a heavy vapor
      d. Face, neck, arms burned?
      e. Probably facing the ignition or holding it
      f. Back of neck or legs burned?
      g. Probably escaping from event
      h. Remember: clothing can protect
         i. Cotton fabrics absorb IR
         ii. Synthetic fabrics can transmit IR

iii. Synthetics melt at temperatures far below what will scorch cotton or wool
iv. Thin fabrics will ignited in flash fires, heavy fabrics will only scorch
v. Cotton/synthetic blend fabrics are the most lethal – easily ignited, loose fitting – rapid burning

7. Mechanical Explosions
   a. When there is no chemical reaction
   b. Compressed gases can still be exciting in a fire
   c. Aluminum Medical Oxygen Cylinder has no relief valve
   d. Boiler explosions – high temperatures in steam and water
8. Meth lab – Case example
9. Honey Oil – Case example
   a. Motel room after flash fire
   b. Butane refills, extraction pipes, MJ, extraction pipe, blender
   c. Signs of occupation and ignition source?

V. Issues of Time Intervals
   A. Fire-to-Death Interval
   B. Scene investigation delays
   C. Post-mortem destruction
   D. Effects of medical treatment

VI. Post-mortem tests
   A. Every fire death deserves a full forensics post-mortem, including toxicology and X-rays.
   B. Toxicology samples should be tested for alcohol and drugs, as well as COHb, and should include both blood and tissue.
   C. The internal (liver) body temperature should be taken as soon as possible, preferably at the scene.

VII. Classification
   A. Cause of death:
      1. Injury or disease that initiates the sequence of events that leads to death
   B. Mechanism of Death
      1. Biological or biochemical derangement that occurs that incompatible with life.
   C. Manner of death:
      1. Circumstances under which the cause is brought about.
      2. Homicide
      3. Suicide
      4. Accidental
      5. Natural
      6. Undetermined

VIII. Pets
   A. Deceased pets should be X-rayed and necropsied
   B. Injuries to living pets should be noted and documented

IX. Conclusion

A. Teamwork – A coalition of talents and knowledge, working together as a team is the only way to get the right answers to the big questions:

1. What killed the victim?
2. Was the fire accidental or deliberate?
3. How did those two events interact?

Sustained Combustion of Bodies: Some Observations

John D. DeHaan, Ph.D.
Elayne Pope, Ph.D.

I. Bodies present complex fuel packages
  A. Layers of different materials with different fire properties
    1. Skin: Proteinaceous
    2. Epidermis: Thin, easily separated at 4-5 kW/m2, 54°C
    3. Dermis: Thicker, higher water content
  B. Subcutaneous fat:
    1. Highest heat content
    2. Low melting point – burns as a viscous liquid
  C. Muscle/tendons:
    1. Proteinaceous, moderate water content, poor fuel – 0.5kJ/g
  D. Bone
    1. Mineral and organic content (collagen)
    2. Fat-rich (marrow and coating)

II. Fire sequence
  A. Epidermis chars away
  B. Dermal layers char, shrink, and split
  C. Subcutaneous fat renders out:
    1. Must burn as a flame (does not smolder)
    2. Most burns from a porous wick (charred clothing, bedding, furniture, carpet, or wood floor)
    3. Most important fuel in a human body
    4. Can support a fire of 20-60 kW involving a typical adult body
  D. Muscle exposed:
    1. Chars and shrinks
    2. Very poor fuel due to protein and water
    3. Shrinkage (muscle and tendons) causes flexion of joints (pugilistic posturing)
    4. Shrinkage occurs first at thinnest locations (joints, skull), exposing bone (from the least massive to most)
  E. Bone exposed:
    1. Organic content chars
    2. Inorganic components shrink, crack, and dehydrate
    3. Fails where exposed to the most heat for the longest

III. Long-term combustion of human cadavers
  A. Tests conducted 2008-2014 under auspices of San Luis Obispo Fire Investigation Strike Team (SLOFIST)
    1. Several refrigerated, unembalmed human cadavers provided by UC-Irvine Medical Center body donation program
    2. Exposed to various non-accelerated fire scenarios

3. Several tests were intended to study long-duration fire exposure of an accidental origin

B. Long-duration test – 2008:

1. Facts of the fire scenario
    a. Cadaver of elderly male, moderately thin
    b. Clothed in cotton sweatshirt and pants
    c. Wrapped in cotton blanket
    d. On modern box spring (thin urethane foam, cloth covering)
    e. Synthetic carpet and pad in open box with 4 ft. ceiling
    f. Ignition with flame to wad of paper at upper edge of blanket
2. Sequence of burning events in photos taken at intervals:
    a. 5 minutes: No fire damage to the body
    b. 7 minutes: Note skin on hand is scorching and blistering
    c. 10 minutes: Right leg is beginning to flex from fire beneath
    d. 12 minutes: Cotton sweatshirt charring away, exposing skin
    e. Hand flexing downward
    f. 14 minutes: Flames at feet. Carpet has ignited below the feet
    g. 16 minutes: Fire has extended length of bed. Right arm is down
    h. 17 minutes: Right arm flexing upward. Fire approaching full involvement
    i. 19 minutes: Arm flexing. Skin on the leg has burned away
    j. 21 minutes: Arm raised
    k. Fingers disarticulated
    l. Head and face involved
3. Post-flashover fire
    a. 22 minutes: Fire engulfing head and torso
    b. Skin on torso burned away
    c. 24 minutes: Arm collapsed
    d. Fire dying back to floor and torso
    e. 35 minutes: Torso fire, ribs are exposed
    f. Fire under torso, legs horizontal
    g. 54 minutes: Left leg flexed. Both broken and disarticulated by fire
    h. 56 minutes:
        i. Plywood floor consumed
        ii. Legs and feet disarticulated
        iii. Flames being fueled by rendering body fat.
        iv. External radiant heat flux: 4-8 kW/m2
    i. 1 hour, 23 minutes: Fire under torso and shoulders
    j. 2 hours, 5 minutes: Sustained fire under torso
    k. 6 hours, 45 minutes: Minimal fire under pelvic area
    l. 7 hours: Fire extinguished and post fire observations
        i. Note that post-fire position of limbs differs from pre-fire
        ii. Note nearly complete combustion of the soft tissues of the torso

iii. Body was removed with bed springs to facilitate documentation
iv. Plastic cling wrap on head to preserve small pieces in place
v. Temperatures: Max 850°C at ceiling. Steady-state: 200-300°C. Temperatures inside torso showed minimal increase over 1 hour.

C. 2009 Test:
  1. Facts of the fire scenario
    a. Body of adult male – cotton clothing
    b. On box spring with cotton blankets
    c. Direct flame ignition of blanket
  2. Sequence of burning events in photos taken at intervals:
    a. Around 1 hour, 50 minutes: Note arm position and ignition of pool under torso
    b. 2 hours, 15 minutes: Arm raised. Large pool of fire under the body
    c. Arm ended up extended at right angle to the body. Note dripped exudates
    d. The remains after 6.25 hours
    e. Temperatures – 2009 Test

D. Burn Barrel Test
  1. Facts of the fire scenario
    a. Human torso and head in wood-fueled burn barrel
  2. Sequence of burning events in photos taken at intervals:
    a. Wildly fluctuating temperatures (depending on location of thermocouple) amid turbulent flames
    b. After refueling and stirring at irregular intervals for 6 hours, there was extensive fragmentation.
    c. Elayne puts out the remaining embers puts the remains through the sieve screen.
    d. Nearly complete cremation from a simple means
    e. Many easily identifiable fragments still remain. A beef vertebrae indicates there were animal parts burned as well.
    f. Bone fragments exhibit charring, calcination, and vitrification from extended exposure to an oxygen-deficient fire

E. Compartment Fires
  1. Facts of the fire scenario
    a. Human torso and head wrapped in blanket on sofa
    b. 1 minute after ignition: No accelerant
  2. Sequence of burning events in photos taken at intervals:
    a. 3 minutes after ignition: Fire engulfs sofa
    b. 4 minutes: Room fire went through flashover
    c. 14 minutes: The remains of the body, near the end of the test
  3. Final results
    a. 11 minutes of post-flashover room fire: Torso still largely intact

b. Head (disarticulated and shot with a small caliber weapon prior to fire) being X-rayed using portable (bomb squad) X-ray.
c. In situ X-ray shows metal fragments from bullet.
d. Head and legs removed pre-fire. Head has been “re-attached”.

IV. Lessons Learned
- A. Sustained fires can do extensive damage to human remains, even if localized
- B. Temperatures can exceed those found in commercial crematoria if there is adequate ventilation.
- C. The patterns of damage can vary with position, environment, and duration.
- D. Fire damage follows a predictable sequence through the layers and can even cause re-positioning of the body.
- E. Careful processing of such scenes can recover critical evidence

V. Acknowledgements
- A. John Madden (San Luis Obispo FD) and other members of SLOFIST
- B. Jamie Novak
- C. Cameron Novak
- D. Mike Whitney
- E. Det. Steve Crawford, San Luis Obispo County Sheriff-Coroner
- F. Bernard Cuzzillo, Ph.D.

Tuesday, Embassy Suites Classroom
Effects of Combustion on Human Remains (con’t) (0800-1200) Dr. Elayne Pope
Effects of Combustion on Human Remains and Fatal Fire Investigation
Elayne J. Pope, Ph.D. www.burnedbone.com

I. Introduction: Research from observations of heat-related changes to the human body in different type of fire scenes (vehicular, structural, and outdoor). Training audience includes Fire Investigators, Law Enforcement, Coroners, Medicolegal Death Investigators, Crime Scene Investigators, and other forensic scientists.
- A. Photographic documentation, intact cadavers with and without traumatic injury (criminal v. accidental)
- B. Burned human remains at the Medical Examiner’s Office: Manner of Death
  1. Accidental (house, vehicle)
  2. Suicide
  3. Homicide where the body is intentionally burned.
- C. What investigators see at the scene and morgue is the end result of a dynamic process (heat & flames), and it becomes difficult to differentiate between Accidental and Homicide as Manner of Death.

II. Early heat-related changes occur to the skin: Color banding, blisters, skin splits
- A. Fire Myth: Blisters indicate vitality. Normal heat-related change of skin exposed to heat that occurs during the fire postmortem: separation of the dermal-epidermal junction of the skin. Research shows that blisters are not an indicator of vitality.
- B. Example of a leg with red and clear fluid filled blisters, along with color banding, skin splits, charred skin, and exposed subcutaneous fat.
- C. The role of clothing= protection.

1. Examples of various skin splits; exposed subcutaneous fat, and rendered fat.
2. An example of the burning continuum on a lower extremity showing blister formation and skin split formation.
3. The role of rendered subcutaneous fat as a fuel source. Pool fire development and rendered fat pool development, following skin splits.

D. The muscular layer is one of insulation around bone.
1. Example of skin split formation, fat rendering, and muscle exposure
2. Compromised abdominal muscle with organ protrusion.
3. Bone becomes exposed as skin, fat, and muscle burn

III. Exposed bone changes color to a yellowish-brown as the pyrolysis zone, then blackened and charred as the organic constituents are pyrolyzed (burned).

A. Most common bone colors are charred and calcined
B. Teeth can also become charred and calcined
C. Bone is similar to wood's heat-related color changes and structural changes during burning.
1. Examples of heat-related colors in wood and bone, showing the order of color changes: normal bone, pyrolysis zone, charred, and calcined (earliest and longest).

IV. Burn patterns occur in layers (i.e. heat transfer through drywall, wood framework, insulation is the same as the layered tissues of the body)

A. Examples of human body layers of skin, fat, muscle, and bone. These anatomical arrangements influence the burn patterns that result on the skeleton.
B. Basic concept: If surfaces of the body were exposed to heat, they will burn, those protected will not burn (shoes on and off), will not burn.
C. Protective role of clothing and areas of direct contact with the floor or other objects during the fire.

V. Pugilistic Posture: Normal heat-related change= flexion of the fingers, hand, wrist, elbow, shoulder, the toes, ankles, knee, and hip.

A. Movement of the body during the fire: variants of the pugilistic position
B. Anatomy of the arm
1. Upper arm (humerus), lower arm (radius and ulna) protected within unique musculature
2. Flexion into the pugilistic posture and heat-related color changes for the upper and lower arm, hand and wrist.
3. Examples of normal burn patterns to the hands: splaying of the fingers, followed by flexion of the fingers followed by flexion of the hand and wrist. This is followed by flexion of the arm at the elbow.
4. Normal burn patterns of the hand and wrist (natural heat-related fracture of the wrist)
5. Natural heat-related fracture of the wrist occurs when extensor tendons have burned away
6. Heat-related color changes in bone and heat-related fractures in the surface of bone.
7. Evidence of the fracture occurring during the fire along with examples of what it looks like after the fire with the hand detached from the forearm.

C. Anatomy of the leg
  1. Upper leg (femur), lower leg (tibia and fibula) protected within unique muscle.
  2. Unique burn patterns associated with the leg: soft tissue and skeletal changes.
  3. Heat-related movement and raising of the legs during the fire
  4. Flexion of the knees and creation of the ballerina pose with the legs spread and toes pointed downward.
  5. Burn patterns of the foot and ankle

VI. Burn sequence
  A. Fleshed orientation
  B. Exposed bone
  C. Color progression
  D. Heat fractures
    1. Examples of curved heat fractures in bone, production and meaning
    2. Normal heat-related changes: warping, shrinkage, and deformation.

VII. Effects of traumatic injury to the burning sequence.
  A. Example: stab wound vs. skin split.
    1. Look for deeper muscle structures of wound.
    2. Causes wound to burn out of the normal burn sequence and as compromised tissues.
  B. Penetrating trauma
    1. Burning of broken bones (penetrating trauma) causes limb deformation and repositioning of the fractured ends within the traumatized musculature.
  C. Open and closed blunt force injuries: differences of burn patterns
    1. Research example of blunt force trauma to the forearm with heat-related changes
    2. Pugilistic posture is still attained of the distal anatomy of the hand and wrist.
    3. Blunt force trauma examples.
  D. Gunshot wound to the lower legs causes fragmentation and limb deformation
  E. Tool marks in burned bone
  F. Fracture morphology of preexisting trauma: angular and patterned.

VIII. Anatomy of the head and face
  A. Protective soft tissue of the face, head, and neck.
  B. Scalp retraction
  C. Protection of the posterior dentition and the oral autopsy
  D. Burn patterns of the mandible
  E. Burn patterns of the skull
  F. Delamination: normal heat-related fracture of the skull: separation of the outer table from the diploe. (examples of delamination)
  G. Normal heat-related fracture production in the skull= shrinking
  H. Traumatic fracture burns differently and was there prior to the fire.
    1. Research on trauma analysis of the skull: Gunshot wounds
    2. Examples of ballistic trauma (entrance, radiating fractures)

        3. Importance of collecting all of the fragments for cranial reconstruction.
        4. Examples of entrance, exit, semi-delaminated entrances, etc.
        5. Radiating fractures into normal, protected bone
        6. Juxtaposition of colors in reconstructed fragments
            a. Blunt force trauma: wound examples of hand-wielded weapons to the head
            b. Sharp force trauma vs. heat fractures in the surface of cortical bone
                1) Linear compaction and pattern vs. meandering and tapering
                2) Post-fire tool marks in bone produce polishing
    I. “Exploded Skull” appearance
        1. Pyrolysis of organic materials leaves bone brittle; deformation, delamination of cranial bone
        2. Examples of the exploded skull appearance
        3. Pink brains
        4. Reason= Suppression!!! Pressurized water hitting the skull causes fragmentation
        5. Along with collapse of fire debris, and selective recovery and transportation habits.

IX. Heat-related changes of the body
    A. Early, Intermediate, Advanced, and Cremation Stages
    B. From ignitable liquids
        1. Clothed vs. unclothed
        2. Pooling at the body-floor junction
        3. Test 1 Face up burned for 6 minutes: Fully clothed on gypsum wallboard
        4. Test 2 Face down burned for 6 minutes as an ignitable liquid fueled fire and then for an hour as a subcutaneous fat fueled fire.
        5. Test 3 Face up on dried palm fronds burned for 1 hour
        6. Test 4 Face up on dried gypsum wallboard burned for 2 hours
    C. Normal heat-related changes for the human body
        1. Blisters
        2. Color banding
        3. Skin splits
        4. Charred skin
        5. Exposed subcutaneous fat.
        6. The role of clothing= protection.
        7. Muscle exposure
        8. Compromised abdominal muscle with organ protrusion.
        9. Bone becomes exposed as skin, fat, and muscle burn
        10. Radiant heat: effects on early movement of the body
            a. Examples of repositioning of the body in recliners
            b. Movement of the extremities as the fire grows and decays
        11. Subcutaneous fat of the torso
            a. Original body weight vs. postmortem weight.
            b. Pool fire development

        c. Liquid demarcation and charring in surrounding flooring

D. Mattress fires
    1. Patterns from coil spring suspension
    2. Movement of the legs
    3. Sagging of the mattress springs

E. Recliner and couch fires
    1. Collapse of the body within the framework
    2. Postmortem fracture of the leg from 1) collapse of the chair 2) suppression

F. Suppression: The effects of pressurized water
    1. Shed fire
    2. Vividly colored soft tissues and bone after suppression
    3. Fallen debris and fire debris
    4. Screening fire debris and processing the scene

G. Structure fire: Trailer
    1. Visibility of evidence following suppression
    2. Effects of an 8 to 15 minute trailer fire

H. Structure fire: Airplane crash into a structure
    1. Role of drywall and fire debris
    2. Dehydration and preservation of the body within deep layers of fire debris.

I. Outdoor criminal fire scenes
    1. Mattress and combustibles over body
    2. Pallets and combustibles under the body
    3. Burn barrel
    4. Metal dumpsters
    5. Physical evidence and mapping

J. Vehicle fires
    1. Ignitable liquids vs. no ignitable liquids
    2. Burn patterns to the body
    3. Motor vehicle crash examples
    4. Accidental v. homicide
    5. Movement of the body during the fire
    6. Effects of suppression
    7. Evidence recovery

K. The body viewed at autopsy
    1. Problems and challenges in the field
    2. Suppression, burial within fire debris
    3. Extraction problems
    4. Fragmentation of the skull from handling, extrication, and transportation
    5. Stabilization of burned bone
    6. Movement of burned human remains
    7. Sealing the body bag
    8. Transportation

L. Analysis of the body at autopsy
    1. Value of fragmentary bone

2. Serial numbers off of surgical hardware
3. Dental restorations
4. Surgical interventions
5. Healed injuries
6. Human v. animal fragments

M. Conclusions and acknowledgements of research

Archeology Methodology (1300-1430) Dr. Alison Galloway

Archaeological Methodology
Alison Galloway
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I. Outline
  A. Preliminaries
    1. Anthropologists
    2. Anthropologist's Contribution
    3. Jurisdiction
  B. Documentation
    1. Photographs
    2. Maps
  C. Types of recovery
    1. Surface
    2. Surface scatter
    3. Enclosed area
    4. Motor vehicles
    5. Burial
  D. Stabilization and Transportation
II. Anthropologists
  A. "Right kind" of Anthropologist
    1. Usually affiliated with a university
    2. Most have archaeological experience
  B. Timeliness and chain of custody
  C. Do we need to bring one in?
    1. Identifiable parts
    2. Smaller bones/fragments
      a. Bring anthropologist to the scene
      b. Email photos to anthropologist
III. Biological Profile
  A. Is it human?
  B. How many individuals involved?
  C. Determination of Sex
    1. Pelvis
    2. Sacrum
    3. Long bones
    4. Skull
    5. Pelvis
    6. Long bones
    7. Skull
  D. Determination of Age
    1. Stages
      a. Fetus/infant
      b. Children age - dental chart

c. Adolescents age - dental eruption
d. Adults age - dental chart
2. Method and estimation variation
a. Fetus/infant
i. age - Infants
ii. age – fontanelle or infant bone
b. Children
i. Range +/- 1 year
ii. Age - epiphyseal chart
iii. Age - epiphyses
c. Adolescents
i. Range +/- 2 years
ii. Age - pubic
iii. Age - pubic2
d. Adults
i. Larger age range
ii. Cementum lines tooth

E. Indications of Ancestry
1. Major features
a. Teeth
b. Nose
c. Shape of face
d. Skull measurements
2. Dentition
a. Shovel incisor
b. Carabellis
c. Crenulated molar
3. Nose
a. Buccal pits
b. Ancestry - gutter sill
c. Nasal sill
4. Shape of face
a. Prominent “cheek bones”
b. Upper lip angle
c. Malar projection
d. Malar projection retreating
e. Skull Lateral Ancestry
5. Thigh bones curvature
a. Femoral Curvature
6. Skull Measurements Fordisc output

F. Stature estimation
1. Humeral length
2. Femoral bicondylar breadth
3. Skeleton front

IV. Individual Identification

A. Major features used

        1. Dentition
        2. Unique features and diseases
        3. Healed injuries
    B. Dentition
        1. Dental pictures
        2. Dental x-ray
    C. Unique features and diseases
        1. Photographs
        2. Radiographs
        3. Eburnation
        4. Auditory exostoses
        5. Arthritis with eburnation
        6. “Surfer’s ear”
    D. Healed injuries examples
        1. Fracture - Recent healing
        2. Fracture - healed tibia2
        3. Fracture - femoral pin
        4. Healed fractures

V. Perimortem trauma
    A. The various forms
        1. Blunt force trauma
        2. Gunshot trauma
        3. Sharp force trauma
    B. Blunt force trauma
        1. Reconstruction
    C. Gunshot trauma
        1. Trauma - GSW entrance
        2. Trauma - GSW int bevel
        3. Trauma - GSW entrances
        4. Trauma - GSW exits
            a. Entrance wounds
            b. Exit wounds
            c. Gunshot Wounds
                i. Trauma - GSW orbit
                ii. Trauma - GSW radiating
                iii. Radiating and concentric fractures
            d. Fracture patterns
                i. Trauma - GSW stain
                ii. Trauma - GSW tear gas
                iii. Trauma - GSW spine
                iv. Trauma - SFT sternum
                v. Trauma - SFT vert
                vi. Trauma - SFT axe
    D. Sharp force trauma
        1. Trauma - SFT femur
        2. dismembered humorous

3. Dismemberment

VI. Postmortem interval
  A. Two major areas of discussion
    1. Time since death
    2. Changes during postmortem interval
      a. Decay stages
      b. Arid conditions
  B. Accumulated Degree Days
    1. Nearest weather stations
    2. Average temperature per day
  C. Total Body Score
    1. Head and neck
    2. Torso
    3. Arms and legs
  D. Limitations
    1. Microenvironment
    2. Effects of scavenging
    3. Proximity to the weather stations
    4. Movement of the remains during decomposition
  E. Season at Death
    1. Cementum annulation
    2. White – April to October
    3. Dark – October to April

VII. Anthropologist on the Scene
  A. Jurisdiction
    1. Anthropologist without a clue…
    2. Example
      a. Former Army base
      b. Given to UC Santa Cruz
      c. Body claimed by Monterey County Coroner
      d. Case involved Seaside Police
      e. FBI involved
  B. Begin the chain of custody
    1. Where will remains go?
    2. How will they be delivered?
    3. What tests can be done given the state of the remains?
  C. Scene processing- Safety First
    1. How can you assess the scene?
    2. How can you enter the scene?
    3. What equipment would you need to ensure safety
  D. Principles for Recovery
    1. What will you need to know later?
      a. Three dimensional
    2. What will someone else need to know?
      a. Criminal or civil cases
      b. Recovery is destructive

c. Scene Location
4. GPS/Total Mapping/GPR
5. Photos
a. Everything is charred
b. Photo log
c. North arrows and Scales
d. Types of photos
i. Approach photos
ii. Exterior views
iii. Interior views (if appropriate)
iv. Throughout recovery
e. Photography
6. Map/Sketch
a. Photos are hard to interpret
b. Associations between evidence and bones
c. Don't have to be artistic
d. Overhead view
7. Photoshop
a. Have sketch map
b. Upload overhead scene photo
c. Add new layer and draw over
E. Equipment
1. Personal protection equipment
2. Forged mason's trowels
3. Scoops
4. Dustpans
5. Buckets
6. Paint brushes
7. Screens – ¼" 1/8"
8. Plastic tarps (clean)
VII. Recovery Challenges
A. Major topics
1. Safety issues
2. CSI Effect
3. Fragile evidence
4. Unpredictability
B. Surface remains
1. Build the Grid
a. Put stakes at corners of boundary
i. Wooden or metal stakes
ii. 90 degree angles
iii. Outside the "recovery scene"
b. String between stakes with light colored string for contrast
2. Size of the Grid
a. Observe the area to be included in grid
b. Can establish series of grids

i. Small enough to allow for easy measurement
ii. Large enough that it is not cumbersome
iii. Commonly use 1 meter/1 yard size

c. Build grid with stakes at corners of boundary

3. The Sanctity of "The Grid"
   a. ….or not
   b. "must be oriented North-South"
      i. If only bodies were …
      ii. Allows for square notation by NS/EW (2N 4E)
      iii. Do need to note N (with date) on map
4. Just a mapping tool!
   a. It can be expanded
   b. Use the scene if appropriate
5. Establish a Datum
   a. Reference point for grid
   b. Used for depth measurements
   c. Must be located in relation to fixed objects

C. Surface Scatter

1. Search
   a. Begin documentation at periphery and work in
   b. Photograph in situ with scale
   c. Dogs can be helpful
2. Clearing the Area
   a. Establish large grid area, if possible
   b. Use total mapping, if available
   c. Clear overgrowth
      i. Check for trace evidence
3. Surface Scatter
   a. Look downhill
   b. Collect everything
4. Items
   a. Photo and bag items separately
   b. ID bones if possible but that can be done in the lab
5. Cremation Scatter (bone cluster, bone in erosion path)
   a. Scenic areas
   b. Map in scatter area
   c. Collect with screening
   d. Over-collect (out crop)
   e. Cremains
      i. Artefacts
      ii. Surgical staples
      iii. Cremation Inclusions

D. Structures and enclosed areas

1. Enclosed Area
   a. Debris coverage
      i. May also give information on pre-fire location

        b. Inevitable damage to remains during recovery
    2. Confusion
        a. Plastics, glass, drywall, etc
        b. Bone smooth exterior, trabecular or rough interior
    3. Clear Area
        a. Map and remove extraneous material
    4. Structure
E. Motor Vehicles
F. Burial
    1. Typical burials of homicides are shallow
    2. Probing for burial pit
        a. Be gentle
        b. Use thin probe
            i. Metal if soil is hard
            ii. Wood if little resistance
        c. Feel for compaction of soil
        d. Don’t stand in grave!
    3. Trowel excavation
        a. Scrape trowel over the surface
        b. Pull towards excavator to form even, clean surface
        c. Begin at the highest point within grid
        d. Soil is removed to dustpan and screened
        e. Work around evidence (leave in situ as long as possible)
        f. Don’t dig!
    4. Why a mason’s trowel?
        a. Edge allows a clean scrape to note color changes
        b. Point delicate enough to isolate material
        c. Can use to “feel” soil for compaction, density and texture
        d. Doubles as North arrow
        e. Fits in back pocket
    5. Uncover vs Extract
        a. Uncover as much as possible before removal
    6. Depth Measurements
        a. Begin prior to excavation
        b. Important to get tops and bottom depths
        c. Pull line with line level from datum
            i. Keep line taut
            ii. Measure directly
    7. Profile
        a. Where in grave are remains?
        b. What could have been damaged?
    8. Wooden instruments
        a. Highly recommended in textbooks
        b. Don’t move much dirt
        c. Helpful in working around bones
        d. Paintbrushes also useful

9. When to go big
    a. Equipment
        i. Shovels
    b. Mechanical
10. Deep Burial
    a. Only dig as deep as you can safely work
    b. Dig side pit if need to go deeper
11. Recovery of Teeth
    a. Normally most stable of elements
    b. Badly destroyed by fire
        i. Anterior teeth lost
        ii. Molars more protected
        iii. Enamel flakes off
        iv. Important for identification
    c. Excavate below the area in which the head was located
    d. Down to consolidated soil level devoid of fragments
    e. If manageable, recover all soil for lab analysis
    f. If not use 1/8” (3mm) screen to isolate fragments
12. Stabilizing for Transport
    a. Pedestal may be good approach
    b. Stabilizing solution
        i. Hair spay
        ii. Dilution of white glue and water
    c. Confounding factors
        i. Chemical analysis
        ii. Toxic screening
        iii. DNA analysis
13. Transportation
    a. Paper bags best for consolidated remains
    b. Ash and debris to be sorted
        i. Plastic tubs with sealable lids
    c. Small remains
        i. Calcined bone very friable
        ii. Small vials with cotton to prevent rattling

G. Equipment List

•Personal protection equipment
•Trowels
•Scoops
•Paint brushes
•Hand brushes
•Dustpans
•Buckets
•Evidence bags
•String
•Line level
•Nails/stakes
•Buckets
•Pointed shovel
•Square shovel
•1/4” screen, shaker or tripod
•1/8” screen
•Graph paper
•Clipboard
•Pencil and markers
•Camera equipment
•Sunscreen, insect repellent, poison oak lotion, etc.

<u>Insect Evidence and Fire Death Investigations (1430-1600)</u>

<u>Dr Robert Kimsey or Dr. Lynn Kimsey</u>

Forensic Entomology for FFDIC
Department of Entomology
University of California
Davis CA

I. Forensic Entomology: an Introduction, or what the Entomologist does
-Historical considerations optional depending on time-
- A. Historical Forensic Entomology
  - 1. First account of forensic entomology- Sung Tz'u, 1235 AD
    - a. Solved slashing murder using flies
    - b. Villagers lay out sickles, flies on one
  - 2. Frenchman, named Bergeret (1855)
    - a. Dead infant, found behind plaster mantle
    - b. Previous not current tenants responsible based on insects present
    - c. First case using insects to determine Postmortem Interval or PMI
- B. Entomology in Civil vs. Criminal Actions
  - 1. Civil case examples
    - a. Alleged Spider bites
    - b. Maggot infestations of patients, elderly
    - c. Infestations of food stuffs
    - d. Infestations of residences
      - i. Fleas
      - ii. Cockroaches
      - iii. Bed bugs
  - 2. Criminal Cases
    - a. Homicides
    - b. Felony abuse, neglect
      - i. Children
        - 1. Age of maggot in diapers
        - 2. Cockroach chewing
      - ii. Elderly
        - 1. Age of maggot in decubitus lesions (bed sores)
      - iii. Animals
        - 1. Maggot infestations in older animals
        - 2. Requires non-issue driven good judgement
        - 3. Maggot infestations in older animals vs maggot infestations together with other evidence of abuse or neglect
- C. The questions most frequently asked:
  - 1. Who was present during an event?
  - 2. Origins or location of an event?
  - 3. Why are insects not present?

4. Significance of a particular arthropod?
    a. Why present?
    b. Effects?
5. When did an event occur- Timing
    a. PMI - post mortem interval
    b. (period of infestation)
6. The PMI: what the Entomologist actually estimates
    a. Not the Post Mortem Interval
    b. The Period of Infestation (PI)

D. Entomological principles employed
1. Life History and Developmental biology
    a. Life cycle
    b. Duration of stages, Life span
    c. Stages of Development
        i. Eggs
            1. Laid in masses
            2. 1.5 - 2mm
            3. 100 – 350 eggs/mass
            4. Often multiple mass piles
        ii. Larvae- three stages called "Instars"
            1. First Instar
            2. Second Instar
            3. Second Instar
            4. Third Instar
            5. Maggot size is an index of age- bigger is older
        iii. Pupae
            1. Color is an index of age
            2. Darker means older
    d. Temperature effects on all these stages: development as a function of temperature
        i. Example: the Green bottle fly Lucilia sericata
        ii. Higher temperature faster development
        iii. Maggot growth rate example
2. Faunal successions- pattern of change in community structure in time
    a. Succession of arthropod taxa on carrion
    b. Insect communities change as the decedent decomposes
    c. The kinds of insects on a decedent may indicate how long the person has been dead
3. Insect effects on decomposition: top-down decomposition
    a. Begins with head
    b. Plural cavity next
    c. Abdominal cavity
    d. Extremities- highly variable
4. Basic biology- how and where an organism lives, why it does what it does
    a. Provides link between persons and places

b. Provides record of the source or travel history of evidence
c. Suggests conditions at the location from which the decedent has been moved

5. Species name the link to biology and life history facts
    a. Calliphoridae - Blow flies, Bottle flies
    b. Sarcophagidae- flesh flies
    c. House fly relatives

II. Sampling the Entomological evidence : What the Investigator (You) Does

A. The intent of Sampling
    1. Provide the necessary study materials to a Forensic entomologist when they cannot get to the scene
    2. Ultimately: to determine the significance of insects in the solution of the crime
        a. Analysis and interpretation of evidence requires Ph.D. level training
        b. We are very few and not readily available on scene

B. What to Sample
    1. The insects
        a. Before removal
        b. After removal
        c. During autopsy
        d. From enclosed structures
    2. The Temperatures
    3. Fixation and Preservation

C. Sampling Theory
    1. Why sample the Insects ?
        a. Acquire specimens for analysis
        b. Determine species
        c. Determine relative abundance
        d. Determine developmental ages
        e. Living material for rearing, establish colonies
        f. Vouchers for later study, evidence

D. When and how to sample insects
    1. Before body removal
        a. Above remains
            i. Aerial insect net
            ii. Sweep nets
            iii. Killing jar
            iv. Dry temporary storage containers
                1. Freezing - hard sided containers with tissue paper
                2. Dry layer boxes in layered tissue paper
                3. Preservation in alcohol, good but last resort
        b. On and around remains
            i. Difficulties with altering state of remains (evidence)
            ii. Collect what can be seen on or around the body

iii. Collect as many as possible, all kinds and stages- eggs through adults
iv. Use forceps various kinds and sizes
1. Individual insects- beetle larvae etc
2. Inefficient for collecting, great for manipulation of specimens
v. Plastic spoons
1. Different sizes
2. Collect maggots in quantity
3. Maggots for rearing easy to lethally damage with forceps
vi. Locations
1. Natural orifices'- on head
2. Wounds
3. Neck, folded skin
4. Hair line
vii. Preservation in Alcohol- 70 % Ethyl or Isopropyl Alcohol are best
1. Labels inside in pencil or Pigma pen
2. 100% cotton rag or some form of archival paper
viii. Collection of living maggots
1. Vented container, chicken parts as food
2. Transport immediately to Entomologist
3. Case number, date, collector, location on remains

2. After removal- exceedingly important in fire investigation
a. Immediately below on or in substrate
i. Gathering surface debris, vegetation under body-
ii. Clothing
iii. Cracks and crevices in soil
b. In purge materials
c. Problematic: some insects small, fast or jump, i.e. piophilid larvae
i. Same tools as on remains plus:
ii. Garden trowel, bulb planter
iii. Aspirators- not sucking types
1. Blowing- venturi
2. Mechanical

3. During autopsy
4. From enclosed structures- restricted access and egress
5. Look for avenues of access, egress
6. Often fewer insects, reduced diversity, slower community development
a. Check window sills
b. Check under edges of carpet- base boards, room corners, baseboard cracks
c. Maggot tracks
d. Beetle frass

E. Temperature measurements

1. Ambient temps
    a. Shaded thermometer in sunlight
    b. Record thermostat temps indoors
2. Surface temperatures
    a. Infrared Thermometers
    b. Surface of remains in numerous places
    c. Surfaces around remains
    d. Surfaces of maggot masses
3. Substrate temperatures
    a. Digital probe thermometers
    b. Under remains
4. Calibrations!!!!!!

F. Preservation
1. Soft bodied insects
    a. Heat (boiling water)- hard to arrange
    b. Alcohol- Very good for all kinds of insects
    c. Other preservatives
    d. Record the kind!!
2. Hard bodied insects and insects collected in air above remains
3. Drying on pins

III. Forensic Entomology and its potential role in fire death investigations

A. Insects common in fire Death with significant time delay between death and fire or fire and discovery
1. Case Example: San Louis Obispo "Homeless" guy
    a. The SLO Scene
    b. The SLO Conditions and autopsy
    c. The insects and what they meant to this case
    d. The research questions posed by entomological evidence in fire investigation, ie what should the fire investigator know

B. Possible histories in Fire-homicide cases (three possible)
1. History of the "normal" homicide- death, delayed discovery
    a. Delay in infestation following death?
2. Homicide, immediate burn, later discovery
    a. Pre and post burn pre-infestation periods?
    b. Characteristic infestation delay following burn?
    c. Change in the progression of infestation?
3. Homicide, later burn, followed by later discovery
    a. All previous plus:
    b. Two detectible infestations?
    c. Viability of prior infestation? (Where & How?)?...
    d. Distinguish prior and subsequent infestations?
4. Homicide, later burn, followed by immediate discovery
    a. Evidence of prior infestation?
    b. Viability of prior infestation? (Where & How?)?

C. The first experiment: Can entomological evidence of significance in fire death investigations?

1. The first general goals: Answer the questions previously posed
    a. Can the pre and post burn pre-infestation periods be estimated?
    b. Is there a characteristic infestation delay following burn?
    c. Pre and post burn infestation evidence?
        i. Evidence of prior infestation?
        ii. Survival of prior infestation?
        iii. Location of prior infestation?
        iv. Distinguish prior and post burn infestations?
    d. Probative value?
2. Experimental design
    a. Includes elements of the previously described case
    b. Modified as a burn pile discarding of body
        i. Followed later by burning (perpetrator returns to scene later)
        ii. Followed even later by discovery
    c. Wounding: S&W 40 cal automatic 30 in away
        i. Two round to chest (center mass)
        ii. One round to center forehead
3. Qualities of the experimental decedents
    a. Four replicates, including one control
    b. White, ~60y previously refrigerated, frozen and defrosted several times
    c. Numerous closed surgical wounds
    d. Clothed: orange prison pants and shirt
    e. State of decomposition: between Initial and Putrefaction: Black-Brown discoloration, Slippage
4. Experimental history
    a. Placement in field day one
    b. Fire on Day Three
        i. Started by flare & 1 L 40% gasoline in 60% diesel
        ii. Quenched by fire hose
        iii. Fuel:
    c. "Discovery" on Day Six
5. Temperature and burn sequence
6. "Discovery" on Day Six
7. Answers to preliminary questions
    a. Post burn pre-infestation period (first fly visit' first egg laid)?
        i. Very low variation
        ii. Slightly longer following burn
        iii. Discuss table of data
    b. Characteristic additional infestation delay following burn?
        i. Insignificant slight delay
    c. Evidence of prior infestation?
        i. Yes! Cohorts of living maggots
    d. Survival of prior infestation?
        i. Yes!

   e. Distinguish prior and subsequent infestations?
      i. Yes! Separation by two life history stages of prior and post burn cohorts
   f. Location of prior infestation and evidence?
      i. In protected locations within skull, under remains

8. Conclusion: Entomological evidence may be highly significant in instances where there are biologically significant delays prior or post burn or in instances where both occur

Forensic Radiology and Imaging Burned Bodies (1600-1700)
Dr. Fred Vernacchia
Assisted by Sergeant J. Nichols
San Luis Diagnostic Center
San Luis Obispo, CA

I. Topics of Discussion
   A. What is Forensic Radiology
   B. When/Why use Radiology or Radiologists?
   C. Why use advanced imaging (CT and MR)?
   D. Illustrate imaging and autopsy findings in burned corpses
   E. Present imaging findings from seminar cases

II. What is Forensic Radiology?
   A. Use of medical imaging to assist legal investigation
   B. X-rays (aka plain films, radiographs)
   C. T (formerly known as CAT scans)
   D. MR (aka MRI)
   E. Subjects: victims, perpetrators, inanimate objects (works of art, mummies, containers)
   F. Accidents, Homicide, Suicide, Abuse, Acts of Terrorism, Smuggling.

III. When/Why use Radiology?
   A. Autopsy refused
   B. Comingled, fragmented, or skeletonized remains
   C. Damage to the body that complicates traditional autopsy
   D. Multiple victims, mass casualty
   E. High profile cases

IV. Why use a Radiologist?
   A. We are not strangers to litigation, deposition, and expert witness testimony
   B. We understand the need for privacy and protection of information
   C. Training in child abuse for all Radiologists has introduced us to the medical-legal needs of forensic investigation
   D. Routine exposure to the “knife and gun” club
   E. Official interpretation and reporting by an expert

V. Why use advanced imaging?
   A. Budget neutral (CT compared to full body or extensive x-rays)
   B. Complete (CT)
   C. Fast (CT)
   D. No artifacts with cross sectional imaging (CT and MR)
   E. Soft tissue detail (MR > CT)
   F. 3D imaging (CT)

G. Fast, head to toe evaluation demonstrating everything one can see with traditional x-rays with significant additional benefits that simply can't be realized with traditional x-rays
   1. Image Examples
      a. Three plane localization of bullet fragments
      b. Infant Death
      c. Suicide, Refused autopsy
      d. Gunshot Wound
      e. Entry Wound
      f. Three dimensional Modeling
      g. Exit Wound
   2. Tremendous potential impact in the courtroom
   3. Forensic and Radiographic Findings in Burned bodies

VI. Goals of Investigation
   A. Victim identification
   B. Alive or dead at the time of the fire? (vitality)
   C. If alive, what prevented escape? (co-morbidity)
   D. Was trauma an antemortem or postmortem injury?
   E. Cause of death
   F. Manner of death

VII. Victim ID by Imaging
   A. Estimates of age, gender, stature
   B. ID of unique implanted devices
      1. Pacemaker
      2. Artificial joints
      3. Dental hardware
      4. Other surgical hardware
   C. Comparison to ante-mortem images
      1. Bone islands and other anatomic variations
      2. Old injuries-Can be used just like dental x-ray)
   D. Examples on slides

VIII. Thermal effects on bodies
   A. Create a spectrum of findings from minor burns to calcined (burned bone reduced to white or blue mineral constituents) skeletal remains
   B. Dependent on:
      1. Temperature
      2. Duration
      3. Type of thermal energy (e.g. radiant heat vs. direct consumption of tissue as fuel)
   C. Burns or consumption of exposed tissue (thermal tissue loss)
   D. Heat related fluid shifts (thermal epidural, false burn blisters, fat emboli)
   E. Tissue shrinkage (pugilistic pose, skin splitting)
   F. Tissue fixation

G. Forensic Pathology Reviews, Vol 1, Tsokos et al

IX. Thermal Effects on Bones
  A. Ordinary house fires (<800 C)
    1. Less than 1% shrinkage
    2. Cracks perpendicular to the long axis may form
    3. Warping in fat/muscle encased bones
  B. Higher temperatures (800-1100 C)
    1. Increased shrinkage
    2. Increased fragility
  C. Burned dry bones may develop longitudinal striae
  D. Even at high temperatures (1100 C and above) the bones retain configuration and internal structure that enables identification by comparison
  E. Fragility of the bones is a concern and investigators should warn Radiology personal to use caution when moving and positioning the body.

X. Effect of Fire on Teeth (Brogden, Forensic Radiology, 1998)
  A. Skeletonized teeth tend to fracture at right angles between the enamel and dentin
    1. Intense heat causes the pulp to boil, exploding the crowns, breaking at the gum line leaving roots behind
    2. Less intense heat exfoliates the enamel, leaving a rounded stump of charred dentin
    3. Black carbonized surface = lower heat = lingual
  B. Skeletonized and Carbonized teeth are fragile
    1. Can be stabilized and preserved with a variety of topical compounds
    2. Root shape can be reconstructed in lost teeth by filling the cavity with radiopaque material
    3. Recovered teeth can be replaced (carefully)
  C. Recent research demonstrated effectiveness of 3D dental images for identification
    1. Use great caution when manipulating or imaging the teeth
    2. Get a Forensic Dentist involved early

XI. Thermal Epidural Hematoma
  A. aka “Heat Epidural”
    1. Clot and marrow expressed from bone
    2. Collects between the bone and dura
    3. Crosses suture lines (traumatic epidurals won’t)
    4. Crosses midline (traumatic subdurals won’t)
    5. No respect for anatomic planes
  B. Thermal Epidural Hematoma Angela Levy, AFIP

XII. Traumatic Epidural Hematoma
  A. Thermal Fractures
    1. Can be difficult to differentiate from fractures due to blunt trauma
    2. Can be caused by falling debris
    3. Easily induced in calcined bones

4. Incineration of the outer table of the skull

XIII. Thermal Tissue Loss
  A. Direct exposure to flame and consumption as fuel
  B. Easily identified
    1. On CT
    2. By visual inspection.

XIV. Skin changes
  A. Splitting –
    1. not to be confused with lacerations
  B. Contracture/Fixation/Shrinkage –
    1. Can change the shape of wounds (e.g. knife wounds)
    2. All can be visualized by CT using surface rendering
  C. Better visualization
    1. With digital surface scanning
    2. or directly visualized

XV. Fat Embolism
  A. Fat droplets in the pulmonary circulation and/or right ventricle
  B. Fat accumulation may also be seen in the epidural space and other body cavities
  C. Can be caused by trauma or less commonly by heat

XVI. Air Embolism
  A. Not seen in a-traumatic deaths (early)
  B. Can be caused by heat effects (“retraction of blood products or formation of coagulum”)

XVII. Imaging Examples:
  A. Blunt Force Trauma
  B. Ballistic Trauma
    1. Burn Case, SLO – Sergeant Nichols to give background of site investigation
    2. Homicide Case, SLO - Sergeant Nichols to give background of site investigation

XVIII. Future Research
  A. Imaging differentiation of pre-existing fractures from those induced by fire
  B. Can the presence of inhaled soot be identified by CT (as it can for sediment in drowning victims).
  C. Is there a role for MRS? ID carboxyhemoglobin in blood, soot in airways, etc.
    1. Down the road.
    2. Questions that come up later.
    3. Copy of the power point outline, or presentation.
    4. Help starting Forensic Radiology examinations in your community.
    5. Assistance interpreting images

<u>Wednesday</u>
<u>Ops Briefing/Scene Overview (0800-0900)</u>
Field Sampling of Entomological Evidence

Danielle Wishon
California Department of Food and Agriculture
Insect Identification Division

I. There are many methods Forensic Entomologists use to collect insects
    A. Nets, killing jars and layering boxes with tissue paper
    B. Forceps or spoons, alcohol vials for preserved specimens
    C. Spoons, dry vials for living samples of eggs and maggots

II. Methods for preservation of insect specimens (evidence) for short and long term evidence and evaluation.
    A. Alcohol Vials
        1. Seventy percent ethyl alcohol for soft bodied insects and life stages; would dry up and shrivel otherwise
        2. A label goes in and on the vial.
            a. The label should include the date, location, case #, and [very important] the preservative in the vial and in what percentage.
            b. Different fixatives, and in different dilutions, effect maggot size; we need to know the percent shrinkage to accurately calculate maggot age.
            c. A vial of maggots stored properly can remain for years in evidence storage.
    B. Dry vials are for adult flies killed in a "kill jar" with a poison, like cyanide or acetone
        1. Also for maggots to keep alive
        2. Live maggots maintained on water ice should get to a forensic entomologist within 24 hours. We will monitor their rate of growth and we rear them to adults to verify identification.

III. Collection should be quick to avoid insect evidence from crawling away
    A. We collect from above, on, and below the decedent.
        1. Above is least essential; don't worry if you don't want to look like a nerd with a net in your squad car.
        2. The most important areas are on and below.
            a. Below, because when maggots pupate they burrow about 5 cm in the ground near the body. Use a trowel to gather dirt samples next to and below the body in a Ziploc
                i. If the body is on a hard surface maggots will crawl away trying to find dirt. Walk from the body and look for brown

hard rice-shaped pupae half in a dry vial and half in a wet vial.
  - ii. On and in the body we use spoons to collect large masses of maggots. Soft tweezers pick maggots from small holes that those of the face. Collect every size maggot you see and some from every area of the body ody.

B. In your case notes record the temperature conditions of the decedent.
   1. Direct sunlight or shade
   2. Outside/inside
   3. Ambient temperature/body temp. If inside, ask the first-on-scene if the window and/or doors were open when they got there or if someone opened them later to deal with the smell.
   4. Discover if the thermostat had been changed since arriving onsite and what it was originally set to.
   5. Use either a number 2 pencil or a micron pen to write labels; outside labels risk this if preservative leaks out onto them

IV. We provide a page with all this information and a list of what you will need for a insect collecting kit. Remember, you may not be able to call a forensic entomologist to the crime scene, so it will be up to you to gather that important evidence before it crawls away."

FIELD EXERCISES
Field Burn Scene Investigations

I. Demo Burn (0900-1000) - Students/Staff

II. Field Exercises (1000-1200) - Students/Staff

A. Field Burn Scene Investigations
   1. Teams investigating their fire fatality scenes
      a. Establishing cause of the fire
         - i. Fire scene investigation
         - ii. Proper reading of fire heat transfer patterns
      b. Proper documentation of the fire scene
         - i. Photographs
         - ii. Sketches
      c. Proper collection of Evidence
         - i. Documentation,
         - ii. Marking and tagging
         - iii. Chain of Custody

B. Proper examination of victim
   1. Coroner’s examination
   2. Proper documentation prior removing the victim
   3. Any evidence of a crime, trauma, etc. at the scene?
   4. Proper removal of the victim

III. Field Exercises - continued (1330-1700) Staff/Students

Thursday – Field Exercises

I. Field Exercises continued (0800-1200)

- A. Field Autopsy (1300-1400) Dr. Gary Walter/Staff
- B. Review of each Scenario Prior to Recovery (1400-1500) Students

II. Field Exercises/Scene Evals with Instructors/Case Prep (1500-1700)

III. Documentation of Case

- A. Field Burn Scene Investigation Report Write Up
- B. Writing the Case Report
  - 1. Organizing the Investigation facts
    - a. Preparing the Evidence and Photographic Logs
      - i. Properly collected, packaged, preserved, marked, and sealed
      - ii. Proper Chain of Custody procedure
  - 2. Preparing the written narrative to establish the cause of the fire and the cause of death
  - 3. Preparing of the Court Exhibits and Diagrams

Friday - Classroom

I. Final Examination 0800-0900

II. Student Case Presentations Student Investigative Team Reports and Reviews 0900-1200

- A. Investigative Team Reviews
  - 1. Presentation by each Investigative Team
    - a. Oral presentations
      - i. Presentation of scene findings
      - ii. Presentation of exhibits
      - iii. Presentation of Evidence
- B. Review by instructors
  - 1. Examination of case to see if there is probable cause of a criminal act established by the Investigative Team

III. Case Presentations continued/Field Reviews/ Presentation of Certificates 1300-1700

IV. Review of class 1700-1800 Instructors/Staff

- A. Review of Examinations
- B. Review of Instructor/course Evaluations