1.1

Forensic Science for High School
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Chapter 1: Introduction to Forensic Science and the Law
Blackline Master
**ACROSS**

1. money to guarantee court appearance
2. type of noncriminal law
3. type of jury with more than twelve jurors
4. evidence that proves something
5. secondhand testimony not admissible in criminal court
6. type of law that excludes hearsay
7. federal agency dealing with drugs
8. agency that investigates mail fraud
9. pseudoscience
10. a serious crime
11. originator of the rule that evidence is always exchanged in an encounter

**DOWN**

1. the study of projectiles, especially with regard to firearms
2. case or _____ law
3. law based on opinions and precedents
4. the study of cause of death
5. “general acceptance” standard
6. major U.S. law enforcement agency
7. legislative acts prohibiting something
8. your rights as defined in a famous 1966 law case
9. _____ contendere
10. revision of the Frye standard
Chapter 1

Puzzle 1.1: Answers

ACROSS

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2. type of noncriminal law
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10. legislative acts prohibiting something
12. your rights as defined in a famous 1966 law case
13. ______ contendere
14. revision of the Frye standard

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Observation: After
CRIME SCENE SCHEMATIC with chapter designations
Evidence Tags

**EVIDENCE**

Case No. \( \hspace{1cm} \) Date

Description of Contents:

**Chain of Custody**

<table>
<thead>
<tr>
<th>Received From</th>
<th>By</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

**EVIDENCE**

Case No. \( \hspace{1cm} \) Date \( \hspace{1cm} \)

Time \( \hspace{1cm} \) Date \( \hspace{1cm} \)

Description \( \hspace{1cm} \)

Removed from \( \hspace{1cm} \)

Address \( \hspace{1cm} \)

Time \( \hspace{1cm} \) Date \( \hspace{1cm} \)

Received by \( \hspace{1cm} \)

Time \( \hspace{1cm} \) Date \( \hspace{1cm} \)
Personal Information File (PIF)

Name: ___________________________  Sex: M  F  Race: ________________

Address: ____________________________________________________________

Phone number: ______________________  Email: ________________________________

Weight: _______  Height: _______  Date of Birth: _______  Place: ________________

Location of scars: ___________________  tattoos: ___________________  piercings: ______________

Blood type: ________________  Color of hair: ________________  Facial hair: ______________

Occupation: ___________________________  Company: ___________________________

Pets:

Hobbies:

Other information:

Fingerprints:

<table>
<thead>
<tr>
<th>R. THUMB</th>
<th>R. INDEX</th>
<th>R. MIDDLE</th>
<th>R. RING</th>
<th>R. LITTLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. THUMB</td>
<td>L. INDEX</td>
<td>L. MIDDLE</td>
<td>L. RING</td>
<td>L. LITTLE</td>
</tr>
</tbody>
</table>
### Matrix: Matching Clues to Suspects

<table>
<thead>
<tr>
<th>Crime Scene</th>
<th>Victim</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingerprints on glassware</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>mug</td>
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<tr>
<td>cup</td>
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<td>paper</td>
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<td>note</td>
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<td>match</td>
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<tr>
<td>cigarette butt</td>
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<td>chair</td>
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<td>pen</td>
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<td>Blood on table</td>
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<tr>
<td>corpse</td>
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<tr>
<td>Hair from corpse</td>
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<tr>
<td>Fiber from fabric</td>
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<tr>
<td>corpse</td>
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<td>Soil from floor</td>
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<tr>
<td>Shoe impression on floor</td>
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<td>DNA from mug</td>
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<tr>
<td>cigarette butt</td>
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<tr>
<td>cup</td>
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<tr>
<td>Glass from floor</td>
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<tr>
<td>Powder on table</td>
<td></td>
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<tr>
<td>Handwriting from note</td>
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<td></td>
<td></td>
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<tr>
<td>Ink from note</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Matches from floor</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Cigarette butt</td>
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<td></td>
<td></td>
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<tr>
<td>Lipstick from cup</td>
<td></td>
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</tr>
</tbody>
</table>

N = no match; Y = a match; NA = not available
Grading Scheme for Expert Witness at Mock Trial

Name of Student: ________________________________________________

Type of Case: ___________________________ Date: ________________

**Dress/Appearance** (5 points maximum) Score: __________
Award all 5 points if witness is wearing dress clothes.

Comments:

**General behavior** (25 points maximum) Score: __________
Eye contact with questioner and jury (or judge). Sits up straight. Speaks clearly and loudly enough to be heard by people in the back of the “courtroom.”

Comments:

**Demonstrates expertise** (30 points maximum) Score: __________
Is knowledgeable about subjects of expertise. Gives clear, concise, scientifically correct answers to questions.

Comments:

**Responsiveness** (30 points maximum) Score: __________
Answers questions asked. Does not volunteer extra or extraneous information. Does not argue with questioner. Does not become flustered.

Comments:

**Effective use of demonstrative evidence** (10 points maximum) Score: __________
Do not award any points if “lawyers” do not call for demonstrative evidence to be used. Make a note below and grade the student on a 90-point basis. If no demonstrative evidence was brought into “court,” do not award any points.

Comments:

Total Score: __________

[An adequate or average performance should earn about 75 points out of 100 total.]
10-print Card

<table>
<thead>
<tr>
<th>Name</th>
<th>Nicknames</th>
<th>DOB</th>
<th>Sex</th>
<th>Height</th>
<th>Weight</th>
<th>Eye Color</th>
<th>Hair Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Tattoos or Piercings: 
Moles, Scars, etc.: 

<table>
<thead>
<tr>
<th>R. THUMB</th>
<th>R. INDEX</th>
<th>R. MIDDLE</th>
<th>R. RING</th>
<th>R. LITTLE</th>
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<table>
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<th>L. THUMB</th>
<th>L. INDEX</th>
<th>L. MIDDLE</th>
<th>L. RING</th>
<th>L. LITTLE</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>LEFT FOUR FINGERS</th>
<th>L. THUMB</th>
<th>R. THUMB</th>
<th>RIGHT FOUR FINGERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
# Fingerprint Lab Activity: Grading Rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10-PRINT CARD</strong></td>
<td>all prints clear and readable</td>
<td>8 prints clear and readable</td>
<td>5 prints clear and readable</td>
<td>all prints on the 10-print card</td>
</tr>
<tr>
<td><strong>IDENTIFICATION OF RIDGE CHARACTERISTICS</strong></td>
<td>2 prints with 12 points identified</td>
<td>2 prints with 8 points identified</td>
<td>2 prints with 6 points identified</td>
<td>2 prints with 4 points identified</td>
</tr>
<tr>
<td><strong>LATENT PRINTS LIFTED FROM A DARK SURFACE</strong></td>
<td>2 prints clear and readable with 3 points identified</td>
<td>1 print clear and readable with 3 points identified</td>
<td>1 print clear and readable</td>
<td>3 latent prints lifted from a dark surface</td>
</tr>
<tr>
<td><strong>LATENT PRINTS LIFTED FROM A LIGHT SURFACE</strong></td>
<td>2 prints clear and readable with 3 points identified</td>
<td>1 print clear and readable with 3 points identified</td>
<td>1 print clear and readable</td>
<td>3 latent prints lifted from a light surface</td>
</tr>
<tr>
<td><strong>CHEMICALLY DEVELOPED PRINTS</strong></td>
<td>use of all 4 techniques</td>
<td>use of 3 techniques</td>
<td>use of 2 techniques</td>
<td>use of 1 technique</td>
</tr>
<tr>
<td><strong>RIDGE CHARACTERISTICS ON CHEMICALLY DEVELOPED PRINTS</strong></td>
<td>2 developed prints, clear and readable with 3 points identified</td>
<td>1 developed print, clear and readable with 3 points identified</td>
<td>2 developed prints, clear and readable</td>
<td>1 developed print, clear and readable</td>
</tr>
<tr>
<td><strong>BEST DEVELOPED PRINT</strong></td>
<td>12 points identified</td>
<td>8 points identified</td>
<td>6 points identified</td>
<td>3 points identified</td>
</tr>
</tbody>
</table>
Dear Parent/Guardian:

During the week of ________________, we will be studying fingerprints in Forensic Science. Your son or daughter will be asked to create a set of prints, lift latent prints from various surfaces, and use physical and chemical techniques to develop latent prints. Several identification systems will be used to compare fingerprints.

The fingerprints will be kept in your student’s notebook. I will not keep or reproduce any of the prints for my records. Due to state privacy laws, your permission is needed for your son or daughter to participate. Please sign the bottom of this letter and return it to me by ________________

Thank you,

I, ________________________________, give my permission for my son/daughter ________________________________ to participate in the fingerprinting activities in Forensic Science class.

Date ________________

Note: All fingerprints will be returned to the students or destroyed at the end of this exercise.
Fingerprint Minutiae

Figure 4.9
**Fingerprint Minutiae: Answers**

![Fingerprint Diagram](image)

- **1. island**
- **2. bifurcation**
- **3. bridge**
- **4. eye**
- **5. ridge ending**
- **6. bridge**
- **7. trifurcation**
- **8. spur**
- **9. bifurcation**
- **10. bifurcation**
- **11. island**
- **12. eye**
- **13. ridge ending**
- **14. bifurcation**
- **15. dot**

**Figure 4.9**
Identification Algorithm

Do these prints match?
Identification Algorithm: Answers

Figure 4.12
Checkpoint Question 1: Matching Fingerprints

From the 20 impressions below, match the ones that are made by the same finger. In some cases, one print may appear two or three times. Some will not match. Write your answers in your notebook or in the space below each fingerprint.
Checkpoint Question 1: Matching Fingerprints: Answers

Matching can be facilitated by digital enlarging and comparing cropped areas, or by enlarging with a photocopier and using a transparency overlay.

A = G = S This one is interesting; there are three separate impressions of the same finger with some very unique features.

B = no match
C = no match
D = no match
E = T
F = J
H = R
I = no match
K = O
L = no match
M = P
N = Q
Case Study: Madrid Bombings. Comparison of fingerprints.

Mayfield

Prime suspect
Puzzle 4.1

ACROSS

2 ______ nitrate for use in developing prints on wood
5 a fingerprint pattern
6 reacts with iodine to form a blue color
9 a government agency
11 a minutia
15 a minutia
16 early pioneer in use of fingerprints
18 fine structure of ridge characteristics
19 number of types of arch
20 area of body with distinctive patterns
22 used to record fingerprints
23 type of loop pattern
24 a minutia

DOWN

1 area of body with ridge patterns
3 type of fingerprint
4 area of a fingerprint
7 subgroup of whorls
8 a map of friction ridges
9 area of body with ridge patterns
10 a minutia
12 one-millionth of an inch
13 removing a fingerprint from an object
14 ______ loop, a whorl
17 a minutia
18 type of fingerprint
21 area of the epidermis

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Puzzle 4.1: Answers

ACROSS

2 ______ nitrate for use in developing prints on wood
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13 removing a fingerprint from an object
14 _____ loop, a whorl
17 a minutia
18 type of fingerprint
21 area of the epidermis

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# Hair Examination Form

Table B5.1 Human Hair Examination and Comparison Form

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Known</th>
<th>Questioned</th>
<th>The Same? Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Type (human, animal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>II. Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Body Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>IV. Tip Condition (frayed, cut, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
<td></td>
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<tr>
<td>V. Length</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
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</tr>
</tbody>
</table>
### Checkpoint Question 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Known</th>
<th>Questioned</th>
<th>The Same? Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI. Shaft Diameter (at root, tip, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
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<td></td>
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<tr>
<td>VII. Configuration (wavy, straight, etc.)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>notes:</td>
<td></td>
<td></td>
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<tr>
<td>VIII. Root (bulbous, absent, sheathed, etc.)</td>
<td></td>
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<tr>
<td>notes:</td>
<td></td>
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<tr>
<td>IX. Cross Section (round, oval, etc.)</td>
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<tr>
<td>notes:</td>
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<tr>
<td>X. Medulla (continuous, none, etc.)</td>
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<tr>
<td>notes:</td>
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<tr>
<td>XI. Medullary Index</td>
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<tr>
<td>notes:</td>
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<tr>
<td>XII. Scale Pattern (imbricate, etc.)</td>
<td></td>
<td></td>
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<tr>
<td>notes:</td>
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</tr>
</tbody>
</table>
### Checkpoint Question 1

**Use Drawings and Notes to Fill Out This Table and Support Your Conclusions. Remember, You May Have to Use This in Court to Refresh Your Memory or to Submit as Evidence.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Known</th>
<th>Questioned</th>
<th>The Same? Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>XIII. Cosmetic Treatment (bleached, dyed, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>notes:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Case Number or Name:** ________________________________

**Date of Examination:** ________________________________

**Conclusions:** _______________________________________

**Signature of Examiner:** ______________________________

**Hair Evidence Information:**

1. Label on known hair samples: ___________________________

2. Label on questioned hair samples: _______________________

---

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Chapter 5: Hair

Blackline Master 5.1c
Puzzle 5.1

ACROSS
4 found in hair root
7 the part of the hair in the follicle
8 a hair configuration
9 key to solving the Ross case
10 the inner portion of a hair
12 possible evidence
15 hair from epidermis to top
16 important property of animal hairs
18 protein polymer common to hair
19 chemical by-product in the body

DOWN
1 tough outer layer of hair shaft
2 a tip condition
3 a cross section
5 found in Napoleon's hair
6 cosmetic treatment
9 telogen hair ends
11 commonest stage of hair growth
13 possible cause of deafness
14 a hair configuration
17 that part of a hair containing fusi
ACROSS

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11 commonest stage of hair growth
13 possible cause of deafness
14 a hair configuration
17 that part of a hair containing fusi
Teacher Demonstration 6.1: Preparation of Nylon 66

Advance Preparation

You could use this as a lab for the class; each lab group would receive a set of materials. You will need a 50-ml beaker and copper wire for a hook. You can also get the student engineer types to construct a roller on which to wind the nylon filament as it is produced. You can purchase hexamethylene diamine and adipoyl chloride separately for just such a demonstration from Flinn Scientific, P. O. Box 219, Batavia, IL 60510; (800) 452-1261; www.flinnsci.com. Flinn also sells a demonstration kit of the two chemical solutions (AP2088). When through, mix both layers well, pull out the remaining nylon, wash it, throw it away, and pour the liquid into a waste container. If you have a hood or a well-ventilated area, let the liquid evaporate away. The amine solution is slightly corrosive to the skin; the chloride solution is flammable and corrosive and has a bit of a smell.

One set for demonstration:
- safety goggles
- 5M NaOH
- 5% hexamethylene diamine in water
- 50-ml beaker
- 6” copper wire
- paper towels

1. Pour 10 ml of a 5 percent aqueous solution of hexamethylene diamine into a 50-ml beaker.
2. Add 10 drops of the 5M sodium hydroxide solution used in the chemical tests.
3. Carefully add 10 ml of the adipoyl chloride in hexane to the solution by pouring it down the wall of the slightly tilted beaker. Two layers will form (see figure), and there will be an immediate formation of a polymer film at the liquid–liquid interface.
4. Using a copper wire hook (a 6-in. piece of wire bent at one end), gently free the walls of the beaker from polymer strings. Then hook the mass at the center and slowly raise the wire so that polyamide forms continuously, producing a strand that can be drawn out for many feet or wound on a makeshift roller. Work carefully; you can break the thread by pulling it too fast.
5. Rinse the polymer several times with water and lay it on a paper towel to dry.

When you are finished making nylon strands, vigorously stir the remainder of the two-phase system to form additional polymer. Decant the liquid into a waste container; do not discard it in the sink. Wash the nylon thoroughly with water and allow it to dry. You can discard it as normal solid waste.

The final product can be colored by adding 1 ml of methyl red, or methyl orange, or bromocresol green to the aqueous amine.

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Table B6.1: Burn Test Results

<table>
<thead>
<tr>
<th>FIBER</th>
<th>BEHAVIOR NEARING FLAME</th>
<th>BEHAVIOR IN FLAME</th>
<th>BEHAVIOR REMOVED FROM FLAME</th>
<th>ODOR</th>
<th>ASH OR RESIDUE</th>
</tr>
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<tbody>
<tr>
<td>cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>linen</td>
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</tr>
<tr>
<td>silk</td>
<td></td>
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</tr>
<tr>
<td>wool</td>
<td></td>
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<tr>
<td>acetate</td>
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<td>rayon</td>
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<td></td>
</tr>
<tr>
<td>olefin</td>
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<tr>
<td>fiberglass</td>
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</table>
# Burn Test Results: Answers

<table>
<thead>
<tr>
<th>FIBER</th>
<th>BEHAVIOR NEARING FLAME</th>
<th>BEHAVIOR IN FLAME</th>
<th>BEHAVIOR REMOVED FROM FLAME</th>
<th>ODOR</th>
<th>ASH OR RESIDUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>cotton</td>
<td>scorches, lights easily</td>
<td>yellow, smoky</td>
<td>continues to burn, glows</td>
<td>burning paper</td>
<td>light gray, feathery ash</td>
</tr>
<tr>
<td>linen</td>
<td>scorches, lights easily</td>
<td>yellow, smoky</td>
<td>continues with afterglow</td>
<td>burning paper</td>
<td>gray, feathery ash</td>
</tr>
<tr>
<td>silk</td>
<td>smolders, then burns</td>
<td>melts and sputters</td>
<td>goes out easily</td>
<td>burning hair</td>
<td>black, shiny beads</td>
</tr>
<tr>
<td>wool</td>
<td>smolders, slow to catch</td>
<td>sizzles as it burns, curls</td>
<td>goes out easily</td>
<td>burning hair</td>
<td>crisp, dark ash</td>
</tr>
<tr>
<td>acetate</td>
<td>fuses away from flame, blackens</td>
<td>lights easily, flickers, melts</td>
<td>continues to burn, small sparks, drips</td>
<td>vinegar, burning wood</td>
<td>black, hard, irregularly shaped beads</td>
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<tr>
<td>acrylic</td>
<td>fuses, shrinks away</td>
<td>flares, puckers, melts</td>
<td>continues to burn and melt, sputters</td>
<td>acrid, fruity</td>
<td>brittle, hard, black beads</td>
</tr>
<tr>
<td>nylon</td>
<td>fuses, shrinks away</td>
<td>burns slowly, drips, white smoke</td>
<td>dies out</td>
<td>celery</td>
<td>hard, round, grayish beads</td>
</tr>
<tr>
<td>polyester</td>
<td>fuses, shrinks away</td>
<td>burns slowly, melts</td>
<td>burns slowly, sooty smoke</td>
<td>tar</td>
<td>hard, round, black beads</td>
</tr>
<tr>
<td>rayon</td>
<td>scorches, lights easily</td>
<td>burns fast, yellow flame</td>
<td>continues to burn, no glow</td>
<td>burning paper</td>
<td>light gray, feathery ash</td>
</tr>
<tr>
<td>olefin</td>
<td>melts, shrinks away</td>
<td>burns, yellow flame</td>
<td>slowly dies out</td>
<td>wax (pe), diesel fuel (pp)</td>
<td>fused plastic</td>
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<tr>
<td>fiberglass</td>
<td>coating burns off</td>
<td>no reaction</td>
<td>no reaction</td>
<td>no odor</td>
<td>may fuse solid</td>
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### Table B6.2: Thermal Decomposition Results

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<th>FABRIC</th>
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<th>RED LITMUS</th>
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<th>RESIDUE</th>
<th>OTHER</th>
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<td></td>
</tr>
<tr>
<td>silk</td>
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<td></td>
</tr>
<tr>
<td>wool</td>
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<td></td>
</tr>
<tr>
<td>acetate</td>
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</tr>
<tr>
<td>rayon</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>olefin</td>
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<td></td>
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# Thermal Decomposition Results: Answers

<table>
<thead>
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<th>FABRIC</th>
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<th>BLUE LITMUS</th>
<th>RESIDUE</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>cotton</td>
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<td>no change</td>
<td>turns red</td>
<td>light gray ash</td>
<td></td>
</tr>
<tr>
<td>linen</td>
<td>no change</td>
<td>no change</td>
<td>turns red</td>
<td>fine gray ash</td>
<td></td>
</tr>
<tr>
<td>silk</td>
<td>brown black</td>
<td>turns blue</td>
<td>no change</td>
<td>melts and fuses together</td>
<td></td>
</tr>
<tr>
<td>wool</td>
<td>brown black</td>
<td>turns blue</td>
<td>no change</td>
<td>black, hollow beads</td>
<td></td>
</tr>
<tr>
<td>acetate</td>
<td>no change</td>
<td>no change</td>
<td>turns red</td>
<td>irregular black beads</td>
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<td>no change</td>
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<td>turns blue</td>
<td>no change</td>
<td>sticky, then hardens to bead</td>
<td></td>
</tr>
<tr>
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<td>no change</td>
<td>no change</td>
<td>turns red</td>
<td>dark beads</td>
<td></td>
</tr>
<tr>
<td>rayon</td>
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<td>no change</td>
<td>no change</td>
<td>black tar, no ash</td>
<td></td>
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<td>olefin</td>
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<td>black melt</td>
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<td>HCl</td>
<td>H₂SO₄</td>
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<td>fiberglass</td>
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</table>

In blends, the warp or woof only may dissolve. Note which one because that can be a significant characteristic.
## Chemical Tests: Answers

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<tr>
<th>FIBER</th>
<th>ACETONE</th>
<th>NaOCl</th>
<th>NaOH</th>
<th>HCl</th>
<th>H₂SO₄</th>
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</thead>
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<td>no change</td>
</tr>
<tr>
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<td>no change</td>
<td>no change</td>
<td>no change</td>
<td>no change</td>
</tr>
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<td>no change</td>
<td>no change</td>
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<td>disintegrates</td>
<td></td>
<td></td>
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<tr>
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<td>no change</td>
<td>no change</td>
<td>no change</td>
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<tr>
<td></td>
<td>disintegrates</td>
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<td></td>
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</tr>
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<td>no change</td>
<td>no change</td>
</tr>
</tbody>
</table>

In blends, the warp or woof only may dissolve. Note which one because that can be a significant characteristic.
Add 500 ml of tonic water to a 600-ml beaker. Place a white background below and behind the beaker to accentuate the color (or lack of) of the solution. Darken the room completely. Shine a black light on the solution. It will fluoresce blue because of the quinine it contains.

In more advanced classes, this can lead to an explanation of transmittance, absorption, emission, and excitation at different wavelengths of light. (This is touched upon in Chapter 7 in the spectrophotometric analysis of aspirin.)

A further demonstration of these phenomena is taken from Flinn’s Chem Fax, Publication #10218 (Flinn Scientific, www.flinnsci.com).

1. Place the tonic water in one 600-ml beaker
2. Add 15 ml of 1% fluorescein solution to a second 600-ml beaker and dilute to 500 ml with distilled water. This will appear yellow-green.
3. Add 5 ml 1% eosin Y solution to a third 600-ml beaker and dilute to 500 ml with ethyl alcohol. This will appear yellow-orange.
4. Add 1 ml of 1% rhodamine B solution to a fourth 600-ml beaker and dilute to 500 ml with distilled water. This will appear pinkish-red.

Place the four beakers in a row with a white background below and behind. With the room darkened, shine the black light on the beakers. They will all fluoresce, but at colors different from those seen under white light. All the solutions can be safely flushed down the drain.
Procedure for Making Your Own TLC Plates

1. Grind together with a mortar and pestle fine-mesh silica gel with about 10% plaster of paris. Add a little zinc sulfide if you want it to fluoresce under UV light.

2. Add about twice as much water and shake vigorously to make a slurry.

3. Spread evenly on a glass or rigid aluminum or plastic sheet, at least 1 inch by 3 inches. A large syringe, without needle, can be used to spread the slurry evenly over the substrate. Then, vibrating or shaking it gently will even out the slurry even more. With some practice, running a knife edge across the plate can also produce a uniform thickness, which should be 0.1–0.25 mm. It is important to have the same thickness on all the plates, otherwise R\textsubscript{f} values may vary.

4. Let the plates air-dry overnight, then activate them in an oven at 110–120°C for 30–45 minutes.

5. When you no longer need the used plates, scrape the silica into a bag or other container and discard as solid waste. Reuse the backing for the next batch of TLC plates.
Appendix A

DEA SCHEDULES OF CONTROLLED SUBSTANCES

Schedule I—Substances that have no accepted medical use in the U.S. and have a high abuse potential. May not be prescribed.

Schedule II—Substances that have a high abuse potential with severe psychic or physical dependence liability. Schedule II controlled substances consist of certain narcotic, stimulant, and depressant drugs. Prescriptions must be written in ink or typewritten and signed by the practitioner except in a genuine emergency, in which case written confirmation within 72 hours is required. No renewals.

Schedule III—Substances that have an abuse potential less than those in Schedules I and II, including compounds containing limited quantities of certain narcotic and non-narcotic drugs. Prescriptions may be oral or written, and up to 5 renewals are permitted within 6 months.

Schedule IV—Substances that have an abuse potential less than those in Schedule III. Prescriptions may be oral or written, and up to 5 renewals are permitted within 6 months.

Schedule V—Substances that have an abuse potential less than those in Schedule IV. Controlled substances consist of preparations containing limited quantities of certain narcotic drugs generally for antitussive and antidiarrheal purposes. These drugs are subject to state and local regulation and a prescription may not be required.
### FEDERAL TRAFFICKING PENALTIES: MARIJUANA

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>1st Offense</th>
<th>2nd Offense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td>1,000 kg or more mixture; or 1,000 or more plants.</td>
<td>• Not less than 10 years, Not more than life.</td>
<td>• Not less than 20 years, Not more than life. If death or serious injury, Not less than 20 years, Not more than life. Fine not more than $4 million individual, $10 million other than individual.</td>
</tr>
<tr>
<td>Marijuana</td>
<td>100 to 999 kg mixture; or 100 to 999 plants.</td>
<td>• Not less than 5 years, Not more than 40 years.</td>
<td>• Not less than 10 years, Not more than life. If death or serious injury, Not less than 20 years, Not more than life. Fine not more than $4 million individual, $10 million other than individual.</td>
</tr>
<tr>
<td>Marijuana</td>
<td>50 to 99 kg mixture; or 50 to 99 plants.</td>
<td>• Not more than 20 years. If death or serious injury, Not less than 20 years, Not more than life. Fine $1 million individual, $5 million other than individual.</td>
<td>• Not more than 30 years. If death or serious injury, Not less than 20 years, Not more than life. Fine $2 million individual, $10 million other than individual.</td>
</tr>
<tr>
<td>Marijuana</td>
<td>Less than 50 kg mixture</td>
<td>• Not more than 5 years.</td>
<td>• Not more than 10 years. Fine not more than $250,000 individual, $1 million other than individual.</td>
</tr>
<tr>
<td>Hashish</td>
<td>10 kg or more</td>
<td>• Fine not more than $250,000 individual, $1 million other than individual.</td>
<td>• Fine $500,000 individual, $2 million other than individual.</td>
</tr>
<tr>
<td>Hashish Oil</td>
<td>1 kg or more</td>
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</tr>
</tbody>
</table>

*Marijuana is a Schedule I controlled substance.*  
*Includes hashish and hash oil.*

[www.usdoj.gov/dea/concern/abuse/chap1/penal/chart2.htm](http://www.usdoj.gov/dea/concern/abuse/chap1/penal/chart2.htm)
## Appendix C: Federal Trafficking Penalties

<table>
<thead>
<tr>
<th>CSA</th>
<th>2nd Offense</th>
<th>1st Offense</th>
<th>Quantity</th>
<th>Drug</th>
<th>Quantity</th>
<th>1st Offense</th>
<th>2nd Offense</th>
</tr>
</thead>
<tbody>
<tr>
<td>I and II</td>
<td>• Not less than 10 years, Not more than life. • If death or serious injury not less than life. • Fine of not more than $4 million individual, $10 million other than individual.</td>
<td>• Not less than 5 years, Not more than 40 years. • If death or serious injury not less than 20 years, or more than life. • Fine of not more than $2 million individual, $5 million other than individual.</td>
<td>10–99 g pure or 100–999 g mixture</td>
<td>Methamphetamine</td>
<td>100 g or more pure or 1 kg or more mixture</td>
<td>• Not less than 10 years, Not more than life. • If death or serious injury not less than 20 years, or more than life. • Fine of not more than $4 million individual, $10 million other than individual.</td>
<td>• Not less than 20 years, Not more than life. • If death or serious injury not less than life. • Fine of not more than $8 million individual, $20 million other than individual.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100–999 g mixture</td>
<td>Heroin</td>
<td>1 kg or more mixture</td>
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<tr>
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<td>1–9 g mixture</td>
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<td>10 g or more mixture</td>
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<td>40–399 g mixture</td>
<td>Fentanyl</td>
<td>400 g or more mixture</td>
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<td>10–99 g mixture</td>
<td>Fentanyl Analogue</td>
<td>100 g or more mixture</td>
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<td></td>
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</tbody>
</table>

### Drug Quantity

- **Others** (Law does not include marijuana, hashish, or hash oil.)
  - Any

### 1st Offense

- • Not more than 20 years.
- • If death or serious injury, not less than 20 years, not more than life.
- • Fine $1 million individual, $5 million not individual.

### 2nd Offense

- • Not more than 30 years.
- • If death or serious injury, life.
- • Fine $2 million individual, $10 million not individual.

### III

- All (Includes anabolic steroids as of 2-27-91.)
  - Any

### 1st Offense

- • Not more than 5 years.
- • Fine not more than $250,000 individual, $1 million not individual.

### 2nd Offense

- • Not more than 30 years.
- • If death or serious injury, life.
- • Fine $2 million individual, $10 million not individual.

### IV

- All
  - Any

### 1st Offense

- • Not more than 3 years.
- • Fine not more than $250,000 individual, $1 million not individual.

### 2nd Offense

- • Not more than 30 years.
- • If death or serious injury, life.
- • Fine $2 million individual, $10 million not individual.

### V

- All
  - Any

### 1st Offense

- • Not more than 1 year.
- • Fine not more than $100,000 individual, $250,000 not individual.

### 2nd Offense

- • Not more than 30 years.
- • If death or serious injury, life.
- • Fine $2 million individual, $10 million not individual.

Source: [www.usdoj.gov/dea/concern/abuse/chap1/penal/chart1.htm](http://www.usdoj.gov/dea/concern/abuse/chap1/penal/chart1.htm)
Appendix D: Infrared Spectra

Appendix D, continued

Appendix D, continued

Appendix E: Mass Spectra

- Caffeine
- Amphetamine
- Barbital
- Aspirin

Appendix E, continued

Appendix E, continued

Puzzle 7.1

ACROSS

2 cocaine
7 a unit of measure in mass spectrometry
8 what this chapter is all about
9 pill dictionary
10 a stimulant
15 charged particle
16 “just say ___”
17 reagent for developing salicylates
20 a type of medicine
22 a Mideastern stimulant
25 possible end of a bad trip
27 abbreviation for marijuana
28 found in a molecule, or James
29 a lysergic acid derivative
30 an analytical spectroscopy method
31 abbreviation for part of the EMS
32 reagent used in spot testing 10 across

DOWN

1 a hallucinogen
2 required for 21 down
3 part of the name for a presumptive color test
4 Saturday night’s supper or ____
5 “Angel ____”
6 a common diluent for heroin
11 contains oxycodin
12 name of a test for 26 down
13 abbreviation for an instrument used in confirmatory testing
14 type of spectrophotometer
18 abbreviation for part of the EMS
19 name of a screening test for 27 across
21 abbreviation for a separatory technique
23 active ingredient of marijuana
24 a very small amount
26 LSD
27 a club drug

Forensic Science for High School
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Puzzle 7.1: Answers

ACROSS

2  cocaine
7  a unit of measure in mass spectrometry
8  what this chapter is all about
9  pill dictionary
10 a stimulant
15 charged particle
16 “just say ___”
17 reagent for developing salicylates
20 a type of medicine
22 a Mideastern stimulant
25 possible end of a bad trip
27 abbreviation for marijuana
28 found in a molecule, or James
29 a lysergic acid derivative
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DOWN

1  a hallucinogen
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3  part of the name for a presumptive color test
4  Saturday night’s supper or ____
5  “Angel ____”
6  a common diluent for heroin
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13 abbreviation for an instrument used in confirmatory testing
14 type of spectrophotometer
18 abbreviation for part of the EMS
19 name of a screening test for 27 across
21 abbreviation for a separatory technique
23 active ingredient of marijuana
24 a very small amount
26 LSD
27 a club drug
ARSENIC TRIOXIDE

1. Product Identification

   Synonyms: Arsenic (III) oxide; arsenic sesquioxide; arsenous trioxide, white arsenic
   CAS No.: 1327-53-3
   Molecular Weight: 197.84
   Chemical Formula: As$_2$O$_3$

2. Composition/Information on Ingredients

<table>
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<tr>
<th>Ingredient</th>
<th>CAS No</th>
<th>Percent</th>
<th>Hazardous</th>
</tr>
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<tbody>
<tr>
<td>Arsenic Trioxide</td>
<td>1327-53-3</td>
<td>99–100%</td>
<td>Yes</td>
</tr>
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</table>

3. Hazards Identification

   Emergency Overview

   DANGER! MAY BE FATAL IF SWALLOWED OR INHALED. CANCER HAZARD. CONTAINS INORGANIC ARSENIC WHICH CAN CAUSE CANCER. Risk of cancer depends on duration and level of exposure. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. MAY CAUSE LIVER AND KIDNEY DAMAGE. USE ONLY WITH ADEQUATE VENTILATION AND RESPIRATORY EQUIPMENT.

   Health Rating: 4—Extreme (Cancer-Causing)
   Flammability Rating: 0—None
   Reactivity Rating: 1—Slight
   Contact Rating: 1—Slight
   Lab Protective Equip: GOGGLES; LAB COAT; PROPER GLOVES
   Storage Color Code: Blue (Health)

   Potential Health Effects

   Inhalation:
   Arsenic may cause inflammation of the mucous membranes with cough and foamy sputum, restlessness, dyspnea, cyanosis, and rales. Symptoms like those from ingestion exposure may follow. May cause pulmonary edema.

   Ingestion:
   Arsenic is highly toxic! May cause burning in esophagus, vomiting, and bloody diarrhea. Symptoms of cold and clammy skin, low blood pressure, weakness, headache, cramps, convulsions, and coma may follow. May cause damage to liver and kidneys. A suspected fetal toxin. Death may occur from circulatory failure. Estimated lethal dose 120 milligrams.
Skin Contact:
May cause irritation, symptoms including redness, itching, and pain.

Eye Contact:
May cause irritation with itching, burning, watering of eyes; may cause conjunctiva damage.

Chronic Exposure:
Arsenic on repeated or prolonged skin contact may cause bronzing of the skin, edema, dermatitis, and lesions. Repeated or prolonged inhalation of dust may cause damage to the nasal septum. Chronic exposure from inhalation or ingestion may cause hair and weight loss, a garlic odor to the breath and perspiration, excessive salivation and perspiration, central nervous system damage, hepatitis, gastrointestinal disturbances, cardiovascular damage, and kidney and liver damage. Arsenic compounds are known human carcinogens and may be teratogenic based on effects in laboratory animals.

Aggravation of Pre-existing Conditions: No information found.

4. First-Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly clean shoes before reuse. Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to this substance.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
If emesis if unsuccessful after two doses of Ipecac, consider gastric lavage. Monitor urine arsenic level. Alkalization of urine may help prevent disposition of red cell breakdown products in renal tubular cells. If acute exposure is significant, maintain high urine output and monitor volume status, preferably with central venous pressure line. Abdominal X-rays should be done routinely for all ingestions. Chelation therapy with BAL, followed by n-penicillamine is recommended, but specific dosing guidelines are not clearly established.

5. Fire-Fighting Measures

Fire:
Not considered to be a fire hazard. Toxic fumes of arsenic trioxide and arsine may be formed in fire situations.
Explosion:
Not considered to be an explosion hazard.

Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures
Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Sweep up and containerize for reclamation or disposal. Vacuuming or wet sweeping may be used to avoid dust dispersal. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll-free number for the US Coast Guard National Response Center is (800) 424-8802.

7. Handling and Storage
Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Wear special protective equipment (Sec. 8) for maintenance break-in or where exposures may exceed established exposure levels. Wash hands, face, forearms and neck when exiting restricted areas. Shower, dispose of outer clothing, change to clean garments at the end of the day. Avoid cross-contamination of street clothes. Wash hands before eating and do not eat, drink, or smoke in workplace. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
- OSHA Permissible Exposure Limit (PEL): 10 ug(As)/m3 ppm (TWA)
- ACGIH Threshold Limit Value (TLV): 0.01 mg(As)/m3 (TWA), listed as A1, confirmed human carcinogen.

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, Industrial Ventilation, A Manual of Recommended Practices, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face high-efficiency dust/mist respirator may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-facepiece high-efficiency dust/mist respirator may be worn up to 50 times the exposure limit, or the maximum use
concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or full-face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

Other Control Measures:
Any area where inorganic arsenic is stored, handled, used, etc., must be established as a “Regulated Area” with controlled access, limited to authorized persons. Containers of inorganic arsenic and Regulated Areas must be labeled to show a CANCER SUSPECT AGENT is present. Eating, drinking, and smoking should not be permitted in areas where solids or liquids containing arsenic or lead compounds are handled, processed, or stored. See OSHA substance-specific standard for more information on personal protective equipment, engineering and work practice controls, medical surveillance, record keeping, and reporting requirements. (arsenic: 29 CFR 1910.1018; lead: 29 CFR 1910.1025).

9. Physical and Chemical Properties

Appearance: Transparent crystals, or white powder.

Boiling Point: 465°C (869°F)

Odor: Odorless.

Taste: Tasteless

Melting Point: 315°C (599°F)

Solubility: 3.7 g/100 ml water @ 20°C (68°F)

Very slightly soluble in diethyl ether.

Soluble in dilute hydrochloric acid, in alkali hydroxide.

Soluble in carbonate solution.

Practically insoluble in alcohol.

Practically insoluble in chloroform.

Soluble in glycerin.

Vapor Density (Air=1): No information found.

Specific Gravity: 3.74

Vapor Pressure (mm Hg): No information found.

pH (1% soln/water): No information found.

Evaporation Rate (BuAc=1): No information found.

% Volatiles by Volume @ 21°C (70°F): 0
10. Stability and Reactivity

Stability: Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products: Emits toxic fumes of arsenic when heated to decomposition.
Hazardous Polymerization: Will not occur.
Incompatibilities: Oxidizers, tannic acid, infusion cinchona and other vegetable astringent infusions and decoctions, iron solutions, rubidium carbide, chlorine trifluoride, fluorine, hydrogen fluoride, oxygen difluoride, acids, bases, sodium chlorate, zinc filings, other reactive metals and mercury. Corrosive to metals in the presence of moisture.
Conditions to Avoid: Incompatibles.

11. Toxicological Information

Toxicological Data: Oral rat LD50: 14.6 mg/kg; investigated as a mutagen, tumorigen, reproductive effector.
Reproductive Toxicity: Has shown teratogenic effects in laboratory animals.

12. Ecological Information

Environmental Fate: When released into the soil, this material may biodegrade to a moderate extent. When released into water, this material may biodegrade to a moderate extent. This material is not expected to significantly bioaccumulate.
Environmental Toxicity: No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: RQ, ARSENIC TRIOXIDE
Hazard Class: 6.1
UN/NA: UN1561
Packing Group: II
Information reported for product/size: 500G

15. Regulatory Information

Federal and State Regulations:
California Prop. 65: This product contains the following ingredients which the State of California
has found to cause cancer, birth defects or other reproductive harm, which would require a
warning under the statute: Arsenic trioxide
California Prop. 65: This product contains the following ingredients which the State of California has
found to cause birth defects which would require a warning under the statute: Arsenic trioxide
California Prop. 65: This product contains the following ingredients which the State of California
has found to cause cancer which would require a warning under the statute: Arsenic trioxide
Connecticut hazardous material survey: Arsenic trioxide
Illinois Chemical Safety Act: Arsenic trioxide
New York release reporting list: Arsenic trioxide
Rhode Island RTK hazardous substances: Arsenic trioxide
Pennsylvania RTK: Arsenic trioxide
Massachusetts RTK: Arsenic trioxide
Massachusetts spill list: Arsenic trioxide
New Jersey: Arsenic trioxide
New Jersey spill list: Arsenic trioxide
Louisiana RTK reporting list: Arsenic trioxide
Louisiana spill reporting: Arsenic trioxide
California Director’s List of Hazardous Substances: Arsenic trioxide
TSCA 8(b) inventory: Arsenic trioxide
SARA 302/304/311/312 extremely hazardous substances: Arsenic trioxide
SARA 313 toxic chemical notification and release reporting: Arsenic trioxide
CERCLA: Hazardous substances: Arsenic trioxide: 1 lb. (0.4536 kg)
Other Regulations:
EINECS: This product is on the European Inventory of Existing Chemicals

16. Other Information

NFPA Ratings:
Health: 3, Flammability: 0, Reactivity: 0
Label Hazard Warning:
DANGER! MAY BE FATAL IF SWALLOWED OR INHALED. CANCER HAZARD.
CONTAINS INORGANIC ARSENIC WHICH CAN CAUSE CANCER. Risk of cancer depends
on duration and level of exposure. CAUSES IRRITATION TO SKIN, EYES AND
RESPIRATORY TRACT. MAY CAUSE LIVER AND KIDNEY DAMAGE. USE ONLY WITH
Adequate Ventilation And Respiratory Equipment.
Label Precautions:
Do not get in eyes, on skin, or on clothing. Do not breathe dust. Keep container closed. Use only
with adequate ventilation. Wash thoroughly after handling.
Label First Aid:
If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. In all cases, get medical attention.

Product Use:
Laboratory Reagent.

Revision Information:
No Changes.

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall we be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, however arising, even if we have been advised of the possibility of such damages.
# Identification of Metals

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<th>NaOH</th>
<th>Confirmatory tests</th>
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<th>Density</th>
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Figure 9.1: Metals Analytical Scheme

Al, Mg, Cr, Cu, Zn, Fe, Pb, Ni

magnetic

Fe, Ni

HNO₃

Fe green

Ni brown

Cu, Cr, Zn, Pb

Density (bromoform)

sinks

HNO₃

rxn, br gas

n.r.

Cu blue

Zn

Pb, Cr

Al, Mg

NaOH

rxn

n.r.

Al

Mg

HCl green

Cr n.r.

Pb
Chromatography Visualization

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<th>UV</th>
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</table>

Laboratory Activity 9.2
Figure 9.4: Qualitative Analytical Scheme

NaHCO₃, CaSO₄, Sucrose, CaCO₃, NaOH
NaCl, Cornstarch, MgSO₄, H₃BO₃, Na₂CO₃

Water

Insoluble

CaSO₄, CaCO₃, Cornstarch

Iodine

Deep blue
Cornstarch

CaSO₄, CaCO₃

Bubbles
CaCO₃, CaSO₄

Vinegar

NaOH, Na₂CO₃

Pink

Na₂CO₃

Sodium Hydroxide

Precipitate

NaHCO₃, Sucrose, NaCl, H₃BO₃, MgSO₄

Sucrose, H₃BO₃, NaHCO₃, NaCl

Vinegar

Bubbles

NaCl, H₃BO₃, Sucrose

Soluble

H₃BO₃

Alcohol

Insoluble

Sucrose, NaCl

Hot Water

Very soluble
Sucrose

Less soluble
NaCl

NaHCO₃
Additional Soil Tests

In the case of class evidence, the more tests that show association, the greater the probative value of the evidence. You may wish to add a few more tests:

A. Testing for nutrients such as nitrate, potassium, and phosphate using a commercial soil or water test kit can sometimes provide comparative information. Kits are readily available from local, county, or state agencies as well as from scientific supply houses. This can relate to soil nutrients, environmental science, and agriculture.

B. Specific chemical tests, such as “salting” a sample, may be necessary for effect. For example, a soluble lead salt added to a soil sample would allow a chromate test; a Fe$^{3+}$ salt could be identified with the bright red thiocyanate complex; reactive metal particles such as Al, Mg, and Zn will produce H$_2$ upon addition of acid, while carbonates (such as limestone, shells, or coral) will form CO$_2$. Specific ion test strips can be used rather than reagents. Specific chemical test strips are available from Fisher Scientific (www.fishersci.com) as EM Quant Test Strips, but they are rather expensive. You may wish to devise your own. One method would be to take a small amount of soil in a 4” test tube, shake it with 1 M HNO$_3$, allow the mixture to settle, pour the supernatant through a filter, and divide it into several aliquots. A 0.1–M solution of silver nitrate will give a milky white precipitate in the presence of chloride ion. Addition of ammonia will give a blue color indicative of copper. Thiocyanate solution (0.1 M KSCN) gives a bright red color with Fe$^{3+}$. Ammonium oxalate (0.1 M) will produce a white precipitate with Ca$^{2+}$, as does 0.1 M barium hydroxide with SO$_4^{2-}$. Many heavy metal sulfides are black. Zinc sulfide, however, is white or may be slightly yellow and is formed by the addition of 0.1 M Na$_2$S. Soluble lead can be detected by shaking a sample of soil in water, not acid, adding a little acetic acid to the filtrate and 0.1 M K$_2$CrO$_4$. A yellow precipitate indicates lead. Test strips for lead in soil can be purchased from some lab suppliers or made (see pages 214–216 in Chapter 8, “Toxicology: Poisons and Alcohol”).

C. Mineralogy: The coarse sands still retain their original mineral composition. Despite identification of more than 2,000 different minerals, only 20 or so are common in soils. Quartz is the most common, with feldspars probably next. Vigorously washing the >20 mesh sieve fraction in water (better is a sonic bath) and then drying yields cleaner particles. Immersion of the sample in oil with a refractive index of 1.53 (mineral oil will do) and observation even under a stereomicroscope can be informative when using crossed polarizers. Tape a film polarizer (such as supplied by Flinn or Edmund Scientific, or borrow one from your physics teacher) over the objective; place another on the lighted stage and rotate it such that no light is transmitted to the eyepiece, then tape it. Most of the common transparent minerals are anisotropic and will show birefringence when the petri dish containing the coarse sand or soil fraction is rotated between the polarizers; however, they cannot be specifically identified in this manner. Nevertheless, the relative number of such particles can be useful; the colors are pretty, and this can lead into a discussion of optical properties of solids, refractive index, optical mineralogy, and the like.
Figure 10.4: Topographic Map of the Martinsville-Mount Horeb Area
Figure 10.5: The Mount Horeb Swamp
Laboratory Activity 10.6: Ghost Crystals

**Materials:**
- Glass jar (approx. 400 mL) with lid
- Ghost Crystals
- Deionized water
- String or yarn (1-2 mm in diam.)
- Petri dish
- Clear plastic vial or 100-mL beaker

**Procedure:**
1. Empty your packet of Ghost Crystals into a clean glass jar (approx. 400 mL) and fill with deionized water to within about 3 cm of the top. Place the lid on and wait a few hours.
2. If bubbles form inside the crystals, try placing the jar in the refrigerator for a few hours to dissolve the excess gas, then remove them, and as the water warms up, the dissolved gas tends to exit at the water’s surface rather than back into the crystals.
3. When the crystals have grown to the point where they appear essentially invisible, pour out four or five of them into a clean petri dish. Although they appear like chunks of glass, they are actually quite rubbery like Jell-O.
4. Choose one of the crystals and, touching it as little as possible, tie a string around it snuggly, but not so tight that it cleaves the crystal in half. This will take some practice!
5. Fill the vial with deionized water, pick the crystal up by the string and lower it into the vial. The crystal will seem to disappear!
6. Show your students the vial of water with the “empty” nozzle inside. Let them examine it closely and postulate if it is even remotely possible that there might be something in the nozzle that we just cannot see. Then lift out the string and show them the tied up crystal. Show them how it disappears as it is placed back in the water.

**Discussion:**
Simply put, because the crystal is made up almost entirely of water, it essentially “looks” like water, and light will pass from the surrounding water into the crystal without being refracted at all. (The crystal and the water are said to have the same index of refraction.) When the crystal is lifted out into the air, it becomes instantly visible: we can see its shape and size because, of course, air’s index of refraction is very different than water’s. It does raise an interesting possibility: if a substance were made that had an index of refraction equal to that of air, would it appear completely invisible in air?

**Ghost Crystals Are Available From Flinn Scientific, Inc.**

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
<th>Price/Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>G0050</td>
<td>Ghost Crystals, 100 g</td>
<td>$6.05*</td>
</tr>
<tr>
<td>G0052</td>
<td>Ghost Crystals, 500 g</td>
<td>15.95*</td>
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</table>


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Angle of Impact of Blood Drops
Checkpoint Questions

15. Calculate the angle of impact for the bloodstains below:

   A  
   w ______ l ______ angle _____

   B  
   w ______ l ______ angle _____

   C  
   w ______ l ______ angle _____

   D  
   w ______ l ______ angle _____

   E  
   w ______ l ______ angle _____

   F  
   w ______ l ______ angle _____

16. Identify what may have caused these types of stains:

   A  
   B  
   C

17. Deduce what happened here:

   A  
   B  
   C
18. Sometimes a transfer pattern can indicate the weapon used in an assault. Guess what made the following:

D_________________
E_________________

A_________________
B_________________
C_________________
D_________________
E_________________
F_________________
G_________________
H_________________
I_________________
J_________________
K_________________
L_________________
DNA Sequence for Use in Activity
“Simulation of DNA Replication Using PCR”

Matt:

AACTGTGGCAGGCATTACCGGTTCACT
GCTAGCCCATGGTAATCCGGACCTACGCTA
TACCGGATCACTATCCGGCATATCCGG
CAT

Tommy:

CGTAGGTCATTGCAATGACTTATCCGGTA
ACCTAGCATATAATGTCCGGCATTCAGTTA
GCCGGCAACTAGTCCGGCTTAGACCGGA
TA

Cindy:

GCTATTACATTCAATAGGTATGTCCGGGC
AGGTATCGCTCCGGCTAGCTATACGTAAT
GACCGGATCAGCTACGGGAGTAGCCGG
CTC

Mike:

ATAGCGTTAGTTACCATATGGTACCGGAT
TAGCATTAATGGATCCGGTACTGATAGT
ACCGTACATATCCGGTCTACTCCGGC
AT

Katie:

TTAGCAGGTATTGGTAATGCTACCGGA
TCTATGGTGGATCAGCCGGTAGCTTAGAT
ACCGGCATCTAAGCCGGGTACCTACCGGC
AT

Nuk:

ATTGGGATAGCTATCGAGGTTAGCCGGC
TAAGCTTACCATGATCCGGTAGCATATG
ATCCGGATCATATGCGGTACCTACCGGA
TAA

DNA from the crime scene:

TACTGTAGGCAGGCTAGGTACACC
GCTAGCATGGTTATCCGGGACAACGCTA
TACCGGATCACTATCCGGGATCATATCGG
CAT
Test Your Knowledge of the Insect World

Circle the letter of the correct answer or true or false.

1. What is a bug?  a) an insect  b) a pest  c) a hidden microphone  d) any or all of the above, depending who you are talking to
2. A person who studies insects is an: a) etymologist. b) insectologist. c) entomologist. d) erythologist.
3. Insects are the most numerous living things on earth: true or false?
4. Taxonomy is: a) the science of taxicabs. b) the classification of things. c) a book in the Bible. d) income tax evasion.
5. What is the proper name for insects with a hard, outer-body casing and jointed legs? a) arthropods b) snails c) mammals d) lobsters
6. Most insects live on land: true or false?
7. The three basic body parts of an insect are: a) head, eyes, tail  b) head, wings, legs  c) head, abdomen, wings  d) head, thorax, abdomen.
8. How many legs does an insect have? a) four  b) six  c) eight  d) any of the above
9. All adult insects have four wings: true or false?
10. Which is not an insect? a) spider  b) ant  c) bee  d) beetle
11. Metamorphosis is: a) a change in the body of insects. b) Sting’s new CD. c) the middle earth. d) a process of extraterrestrial travel.
12. Larva is: a) a Hindu god. b) a volcanic rock. c) the immature stage of insect development. d) a skin disease.
13. Exoskeleton is: a) the outer structure of a spacecraft. b) the tough outer covering of insects. c) X-man’s skeleton. d) bones found in the woods.
14. Hypothetically, if a pair of houseflies bred in April, and all offspring lived, how many flies would there be by August? a) $10^5$  b) $10^{10}$  c) $10^{15}$  d) $10^{20}$
15. Label the parts of this house fly as indicated in the diagram:

16. Label the parts of this beetle as indicated in the diagram:
Table 13.1: Soil Specimens

<table>
<thead>
<tr>
<th>No. Found</th>
<th>No. of Body Segments</th>
<th>No. of Pairs of Legs</th>
<th>No. of Pairs of Wings</th>
<th>Common Name</th>
<th>Class &amp; Order</th>
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</thead>
<tbody>
<tr>
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<td>10</td>
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</tbody>
</table>
Key to Insect Orders
Key to the Adult Stage of Insect Orders

1. (a) Insect with wings ............................................... 2
   (b) Insect without wings ........................................ 28

2. (a) Front wings hardened, leathery or parchment-like, at least at the base .................... 3
   (b) Front wings membranous .................................. 8

3. (a) Chewing mouthparts ......................................... 4
   (b) Sucking mouthparts ......................................... 7

4. (a) Without pincer-like cerci .................................... 5
   (b) With pincer-like cerci (earwigs) ...................... DERMAPTERA

5. (a) Front wings with branched veins ....................... 6
   (b) Front wings hard, without veins (beetles) ........... COLEOPTERA

6. (a) Jumping insects; hind femur enlarged; tarsi with four or fewer segments (crickets, katydids, grasshoppers) .................. ORTHOPTERA
   (b) Walking insects; hind femur not enlarged; tarsi with five segments (roaches, mantids, walking sticks) .................. DICTYOPTERA

7. (a) Front wings leathery at base, membranous at end (true bugs) ......................... HEMIPTERA
   (b) Front wings of uniform texture (leafhoppers, treehoppers, spittlebugs, cicadas, aphids) ...................... HOMOPTERA

8. (a) Two wings ......................................................... 9
   (b) Four wings ..................................................... 13

9. (a) Pronotum extending over abdomen (pigmy grasshoppers) ....................... ORTHOPTERA
   (b) Pronotum not extended over abdomen ........... 10

10. (a) End of abdomen without noticeable appendages ............................................. 12
    (b) End of abdomen with style or thread-like tails  11
11. (a) Style-like tail (male scales) .......... HOMOPTERA
(b) Two or three thread-like tails (mayflies) ........ EPHEMEROPTERA

12. (a) With haltere-like organs in front of wings (male stylopids) .......... STREPSIPTERA
(b) With halteres behind wings (mosquitoes, flies, gnats, midges) .......... DIPTERA

13. (a) Wings usually covered with scales; mouthparts consist of a coiled proboscis (butterflies, moths) .......... LEPIDOPTERA
(b) Wings with few or no scales; without coiled proboscis ............. 14

14. (a) Very slender wing with fringe of hairs as long as wing is wide (thrips) .......... THYSANOPTERA
(b) No fringe of hairs, or if present, not as long as wing is wide ............. 15

15. (a) Hind wings equal to, or larger than front wings ...................... 21
(b) Hind wings smaller than front wings ...................... 16

16. (a) No long abdominal tail-like appendages .................. 17
(b) Abdomen with two or three thread-like tails (mayflies) .......... EPHEMEROPTERA

17. (a) Tarsi two or three segmented .................. 18
(b) Tarsi with more than three segments (usually 5) ............. 20

18. (a) Piercing-sucking mouthparts (leafhoppers, plant hoppers, spittlebugs, aphids, cicadas) .......... HOMOPTERA
(b) Chewing mouthparts .................. 19
Laboratory Activity 13.1

19. (a) Cerci present (zorapterans) .......... ZORAPTERA

(b) Cerci absent (booklice, barklice) PSOCOPTERA

20. (a) Antennae shorter than body, not noticeable scales (bees, wasps, ichneumons) HYMENOPTERA

(b) Antennae as long as body; wings and body often with hairs (caddisflies) TRICHOPTERA

21. (a) Mouthparts close to eye .................................. 22

(b) Mouthparts at end of beak-like structure some distance from the eye (scorpionflies) MECOPTERA

22. (a) Wings never held flat over abdomen .......... 23

(b) Wings held flat over abdomen .................. 25

23. (a) Bristle-like inconspicuous antennae (dragonflies, damselflies) ODONATA

(b) Antennae apparently with several segments 24

24. (a) Hind wings with enlarged anal area folded fan-like; wings tend to curl around the body lengthwise (dobsonflies, fishflies, alderflies) MEGALOPTERA

(b) Hind wings without enlarged, folded area; wings do not tend to curl around body lengthwise (lacewings, mantispids, ant lions, owl flies) NEUROPTERA

25. (a) All legs of walking type .......................... 26

(b) Hind legs modified for jumping (tree crickets) ORTHOPTERA

26. (a) Basal segment of front tarsus has swollen appearance (webspinners) EMBIOPTERA

(b) All tarsal segments approximately equal in size 27
27. (a) Cerci usually long; more than 8 segments (stoneflies) ........................................ PLECOPTERA
   (b) Cerci short; with 2 to 8 segments or absent (termites) ........................................ ISOPTERA

28. (a) Antennae present ........................................ 29
   (b) Antennae absent ........................................ 40

29. (a) Mouthparts usually withdrawn or enclosed in the head and not apparent .................... 30
   (b) Mouthparts usually distinctly apparent ........ 31

30. (a) Collophore present; spring-like organ usually present (springtails) .................... COLLEMBOLA
   (b) Both collophore and spring-like organ absent; distinct cerci present ...................... DIPLURA

31. (a) Long tail-like appendages absent ............... 32
   (b) Three tail-like appendages present (silverfish, firebrats) ....................................... THYSANURA

32. (a) Body flattened laterally or dorsoventrally ...... 33
   (b) Body not flattened ....................................... 43

33. (a) Body flattened laterally (fleas). SIPHONAPTERA
   (b) Body flattened dorsoventrally ........................ 34

34. (a) Sucking mouthparts externally visible ........ 35
   (b) No sucking mouthparts externally visible ........ 36

35. (a) Antennae longer than head (true bugs) ........
       ....................................................... HEMIPTERA
   (b) Antennae shorter than head (louse flies, bat flies) ................................................ DIPTERA

36. (a) Antennae longer than head ........................ 37
   (b) Antennae shorter than head ......................... 39

37. (a) Basal segment of front tarsus swollen (web spinners) ....................................... EMBIOPTERA
   (b) Basal segment of front tarsus not swollen ...... 38
38. (a) Tiny insects; tarsi 2 to 3 segmented (booklice, barklice) ........................................ PSOCOPTERA

(b) Large insects; tarsi five segmented (cockroaches) .......................... DICTYOPTERA

39. (a) Head wider than thorax at point of attachment to thorax (chewing lice) ........... MALLOPHAGA

(b) Head narrower than thorax at point of attachment to thorax (sucking lice) .......... ANOPLURA

40. (a) Legs present .................................................. 41

(b) Legs absent .................................................. 42

41. (a) Fewer than 12 abdominal segments (bat flies, louse flies) ............................. DIPTERA

(b) Twelve abdominal segments (proturans) ................................................................. PROTURA

42. (a) Head and thorax separate (scale insects) ................................................................. HOMOPTERA

(b) Head and thorax fused (female stylopids) ............................................................... STREPISIPTERA

43. (a) Abdomen and thorax narrowly joined together (ants) ................................................ HYMENOPTERA

(b) Abdomen and thorax broadly joined together .......................................................... 44

44. (a) Body covered with scales (female cankerworms) ................................................... LEPIDOPTERA

(b) Body not covered with scales .......................................................... 45

45. (a) Tarsal claws absent (thrips) .......................................................... THYSANOPTERA

(b) Tarsal claws present .................................................. 46

46. (a) Piercing-sucking mouthparts .......................................................... 47

(b) Chewing mouthparts .......................................................... 49

47. (a) Cornicles usually present (aphids or plant lice) .............................................. HOMOPTERA

(b) Cornicles absent .................................................. 48
48. (a) With distinct head and eyes (bed bugs) .............
................................................. HEMIPTERA

(b) Without distinct head and eyes (female scales) ...
.............................................. HOMOPTERA

49. (a) Abdominal forceps present (earwigs) ............
.............................................. DERMAPTERA

(b) Abdominal forceps absent ......................... 50

50. (a) Mouthparts at end of beak like structure some
distance from eye (scorpionflies). MECOPTERA

(b) Mouthparts not elongated, close to eyes ...... 51

51. (a) Cerci present ....................................... 53
(b) Cerci absent .......................................... 52

52. (a) Antennae longer than one-third of body length
(booklice, barklice) ......................... PSOCOPTERA

(b) Antennae shorter than one-fourth of body length
(female stylopids) ......................... STREPSIPTERA

53. (a) Body leathery and usually grey or dark colored ...
................................................. 54
(b) Body soft and pale colored ...................... 57

54. (a) Hind legs adapted for jumping .... ORTHOPTERA

(b) Hind legs not adapted for jumping ............. 55

55. (a) Pronotum narrow, body pencil-like or stick-like ...
................................................... PHASMIDA

(b) Body not elongated and stick-like ............... 56

56. (a) Front legs enlarged grasping type (mantid) ....
................................................ DICTYOPTERA

(b) Front legs not enlarged, pronotum broad and
flattened, frequently pronotum covers head
(cockroach) .................................. DICTYOPTERA
57. (a) Two tarsal segments (zorapterans) .................. ZORAPTERA

(b) Three to five tarsal segments .......................... 58

58. (a) Basal segment of front tarsi with swollen appearance (webspinners) .......... EMBIOPTERA

(b) Basal segment of front tarsi about same size as ones immediately following (termites) ............... ISOPTERA
The Effects of Temperature on Rearing of Maggots

Location: _________________________________ Genus: ______________________ Group:_____________

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed time, hrs</th>
<th>T, °F</th>
<th>Appearance</th>
<th>Size, mm</th>
<th>Comments</th>
<th>Initials</th>
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</table>

Laboratory Activity 13.3
Laboratory Activity 13.3

Effect of Temperature on Growth

Time to 3rd Instar, number of days

Temperature, degrees Centigrade
Lab Activity 13.3: Larvae Growth

Graph showing the growth of larvae over time. The x-axis represents the day number, ranging from 0 to 11, and the y-axis represents the larva length in mm, ranging from 4 to 18. The graph shows an upward trend in larva length over time, peaking around day 9 and then declining slightly.
**ACROSS**

1. shedding insect’s outer skeleton (4)
2. mid-portion of an insect (6)
3. government agency (3)
4. harvest larvae to find ______ (5)
5. a taxonomic category (5)
6. self-destruction of a cell (9)
7. a unit of measure of absorbed biological energy (9)
8. the family of carrion beetles (9)
9. goes with 3 across (5)
10. a corpse (7)
11. founder of the Body Farm (4)
12. unit of biological energy input (3)
13. final taxonomic classification (7)
14. related to time of death (3)
15. fly bait (5)
16. late 3rd instar (7)
17. preferred corpse for entomological research (3)
18. a smelly chemical of death (10)
19. a corpse to beetles (4)
20. type of beetle last to arrive at corpse (4)
21. flesh flies (13)
22. fly family (7)
23. hardened forewing of a beetle (7)

**DOWN**

1. first to arrive at a corpse (3)
2. used to identify fly eggs and early instar (3)
3. a taxonomic category (5)
4. related to time of death (3)
5. fly bait (5)
6. killing solution (7)
7. flesh flies (13)
8. the family of carrion beetles (9)
9. a taxonomic category (5)
10. unit of biological energy input (3)
11. final taxonomic classification (7)
12. late 3rd instar (7)
13. preferred corpse for entomological research (3)
14. related to time of death (3)
15. fly bait (5)
Puzzle 13.1: Answers

ACROSS
1 shedding insect’s outer skeleton (4)
3 government agency (3)
4 harvest larvae to find ______ (5)
6 self-destruction of a cell (9)
9 goes with 3 across (5)
10 a corpse (7)
11 founder of the Body Farm (4)
14 family of the cheese skipper (11)
18 a smelly chemical of death (10)
19 type of fly (5)
21 a unit of measure of absorbed biological energy (9)
22 fly family (7)
23 hardened forewing of a beetle (7)

DOWN
2 mid-portion of an insect (6)
3 first to arrive at a corpse (3)
4 used to identify fly eggs and early instar (3)
5 a taxonomic category (5)
6 killing solution (7)
7 flesh flies (13)
8 the family of carrion beetles (9)
12 unit of biological energy input (3)
13 final taxonomic classification (7)
14 related to time of death (3)
15 fly bait (5)
16 late 3rd instar (7)
17 preferred corpse for entomological research (3)
19 a corpse to beetles (4)
20 type of beetle last to arrive at corpse (4)
Activity 14.1

Skeleton

1. _____________
2. _____________
3. _____________
4. _____________
5. _____________
6. _____________
7. _____________
8. _____________
9. _____________
10. _____________
11. _____________
12. _____________
13. _____________
14. _____________
Determining Sex Using the Os Pubis
Determining Sex Using Skull Features

Look at the two skull diagrams below, noting the differences. Circle the differences and use an anatomy textbook to name the points circled. Determine the sex of the skeleton provided for class observation based on skull features.
Determine the age of the model skeleton based on the various epiphyses.
7. Use Table 14.2 to determine the approximate age of each specimen in the photo below.
# Laboratory Activity 15.1

**Bullet Worksheet**

<table>
<thead>
<tr>
<th>Designation or Exhibit #</th>
<th>Detailed drawing of entire bullet</th>
</tr>
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<tbody>
<tr>
<td>Condition (entire, deformed, etc.)</td>
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<tr>
<td>Diameter, inches</td>
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<tr>
<td>Diameter, mm</td>
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<td>Length, mm</td>
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<td>Caliber</td>
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<td>Weight, grams</td>
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<tr>
<td>Weight, grains</td>
<td></td>
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<tr>
<td>Type (jacketed, round nose, etc.)</td>
<td></td>
</tr>
<tr>
<td>Number of lands or grooves</td>
<td></td>
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<td>Width of land, mm</td>
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<td>Width of groove</td>
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<td>Direction of twist (left or right)</td>
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<td>Striae present (Y or N)</td>
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<td>Number of rows of cannelures</td>
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<tr>
<td>Remarks:</td>
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</tbody>
</table>

Signed ___________________________ Date ____________ Supervisor’s initials ___________________________
**Cartridge Case Worksheet**

Designation or Exhibit # ________

Condition (clean, rusty, etc.) ________

Diameter, inches ________

Diameter, mm ________

Length, mm ________

Caliber ________

Head stamp ________ or imprint

Case finish (brass, nickel, etc.) ________

Centerfire or rimfire ________

Firing pin impression (rectangular, round, etc.) ________

Breech mark pattern (parallel, circular, etc.) ________

Extractor mark description ________

Ejector mark description ________

Magazine scratches (Y or N) ________

Chamber marks (Y or N) ________

Remarks:

Signed ___________________________ Date ____________ Supervisor’s initials ________________

detailed drawing of entire cartridge case

drawing extractor mark
drawing ejector mark
Simulated Sodium Rhodizonate Test
Checkpoint Question 18: Matching Shoeprints

Do any of these shoeprints match?
Puzzle 15.1

SERIAL EJECTOR V T
LANDSF PA GRIFLED
STANCE IRNRBLSB
RESTORATION LIH
JCLTWBAEMUMXSO
BHASUREBHERL
A VNDGRYSUAROG
L XENGRQJATHAO
LBMLGEFIAARCCFW
IEIGRSLLJKAEMGP
SRATOBPURETHGO
TPSDOCTRPCWANI
IAHUVRXBSEMUIAN
CHAYEEZTHWSVTST
SJCASEBARIUMGTM

ATF
ballistics
barium
bore
breech
bullet
cannelures
case
cast
chamber
ejector

extractor
gait
gauge
grain
grooves
GSR
hollowpoint
IBIS
lands
lead
oblique

primer
restoration
rifled
SEMEDX
serial
slug
stance
striae
twist
VIN
Puzzle 15.1: Answers

SERIALEJECTORTV
LANDSFPAGRIFLED
STANCEIRRNRBLSB
RESTORATIONLILH
JCLLTWBAEMUMXSO
BHASUXRWSBEHERL
AAVNDGRYSUAROGL
LMXENGSRQJATHAO
LBMLGEFIARCCFW
IEIGRSLJKAEEMGP
SRATOBPURETHGEO
TPSDOOCTRPCWANI
IAHUVRXXBSEMUTAN
CAYEEZTHWSTDST
SJCASEBARIUMGMT
Simulated Forgery

A. Write your name (signature):

B. Write your name again:

C. (Leave blank):

D. (Leave blank):

E. Have someone copy your signature (after practicing on scrap paper):

F. Have someone else copy your signature (after practicing on scrap paper):

G. Disguise your signature:

H. Write “Cleopatra”:

I. Have person E copy this:

J. Write “Cleopatra” but disguise your handwriting:

K. Write “ninety-six”: 
L. Have person F copy this:

M. Write “ninety-six,” but disguise your handwriting:

N. Write the numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9:

O. Have E copy the numerals:

P. Have F copy the numerals:

Q. Write the numerals in disguised writing:

R. Go back to C and D and write your signature again. Examine your four signatures and note the differences based on the 12 characteristics described in the text:

S. Note similarities between your normal handwriting and your disguised handwriting in G, J, M, and R. Normally you alter the major characteristics of your handwriting, but the minor ones give you away. What major characteristics from the 12 points did you change? What minor ones remain?

T. Examine some of the signatures made by your classmates in E, F, L, I, O, and P. Comment on some of the primary signs of forgery, and note which ones have:
   a. the appearance of being written slowly
   b. blunt line endings and beginnings
   c. poor line quality, with wavering and tremors of the line
   d. retracing and patching
   e. stops in places where writing should be free and smooth
   f. inconsistent letter formation