Crime Busters

Worksheets

Created by: Sarah Morgan

Table of Contents

<u>Fibers</u>

For this event, we will be identifying fibers as either animal, vegetable, or synthetic. The easiest way to do this is to perform burn tests on them. In a burn test, the fiber is held using forceps just above a flame. The fiber should NOT touch the flame.

Animal fibers include silk and wool. In a flame test animal fibers will burn and smell like burning hair because they are.

Vegetable fibers include cotton and linen. In a flame test plant fibers will turn black and burn.

Synthetic fibers include, but are not limited to, nylon, spandex, and polyester. In a flame test man-made fibers will melt almost immediately.

Practice:

Identify which category each fiber would belong to:

1) Wool - _____

2) A fiber that melts - _____

3) A fiber that smells like burning hair - _____

4) Linen - _____

5) Nylon - _____

6) A fiber that turns black - _____

7) Silk - _____

8) Cotton - _____

9) Spandex - _____

10) A fiber that burns - _____

BONUS rayon - _____

Spatters

Spatter analysis is the interpretation of bloodstains. For this event we will focus on determining speed and direction of impact.

The simplest type of analysis is separating transfers from spatters. Transfers occur when a blood source comes in direct contact with a target surface, whereas a spatter occurs when blood is acted upon by force, and travels through the air before landing on a target surface.

Spatters are classified by speed in three categories: low velocity, medium velocity, and high velocity.

Speed	Force	Shape	Source
low velocity	normal gravity (5-25 ft/sec	large, circular, diameter >4mm	open wounds, surfaces saturated with blood
medium velocity	greater than normal gravity (>25 ft/sec)	majority of larger drops broken into smaller spatters, diameter 2-4mm	blunt force, stabbings, secondary spatters
high velocity	>100 ft/sec	mist like appearance, diameter <2mm	gunshots, explosions, high speed collisions

The direction of impact can be determined just by looking at the spatter. The "tail" points to the direction of the blood drop. If there are multiple drops, draw lines through the tails. The spot where these lines meet is the origin of the spatter.
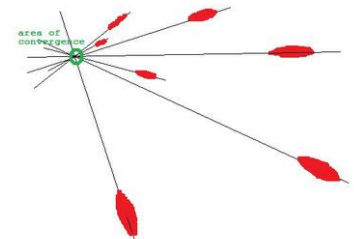
Practice:
Identify if each picture is a transfer or a spatter. If it's a spatter identify its speed.

a)_____

b)_____

c)_____

d)_____   4
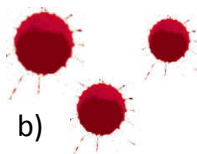
Chromatography

Chromatography is used to separate the colors of ink. In order to perform a chromatography there is a specific process that you must do.

1. Put a dot of ink about 1 inch from the bottom the piece of chromatography paper
2. Put less than 1 inch of water in a large glass beaker
3. Line up the paper with the outside of the beaker so that the bottom of the paper would be about half an inch in the water.
4. Using a pencil poke a hole in the paper where the top of the beaker lines up with the paper
5. Carefully place the paper in the beaker, using the pencil to prevent the paper from falling in the water
6. Let the chromatography run for about 30 minutes or until the ink has reached the top

REMEMBER Do not let the ink dot touch the water

Place your finished chromatography in the box below
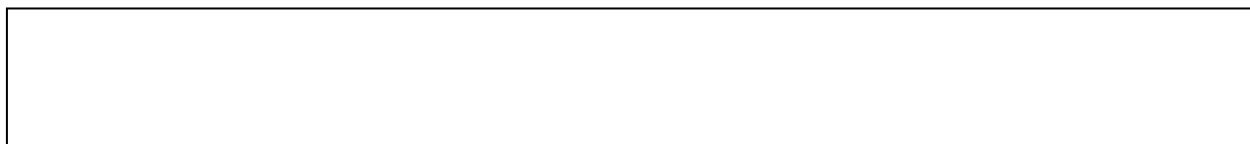
In the event always start the chromatography at the beginning of the event because it takes awhile. You can do the rest of the test while it's going. Once it is done, compare your results with the known results, to determine which pen the ink came from.

Also, you may be asked to calculate the Rf, or the retention factor for a chromatogram. Rf is a measure of how far the ink travels in the solvent (usually water). It is calculated by dividing the distance the solute (ink) traveled (D1) by the distance traveled by the solvent front (water) (D2).

$$Rf = D_1 / D_2$$
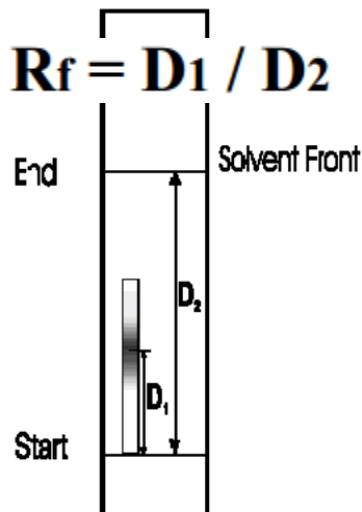
Practice:
Calculate the Rf of each chromatogram

1) A chromatogram has a D1 of 5 and a D2 of 15:_____

2) A chromatogram has a D1 of 7 and a D2 of 20:_____

3) A chromatogram has a D1 of 2.5 and a D2 of 10:_____

Calculate the Rf of your chromatogram:

D1:_____   D2:_____   Rf:_____

End

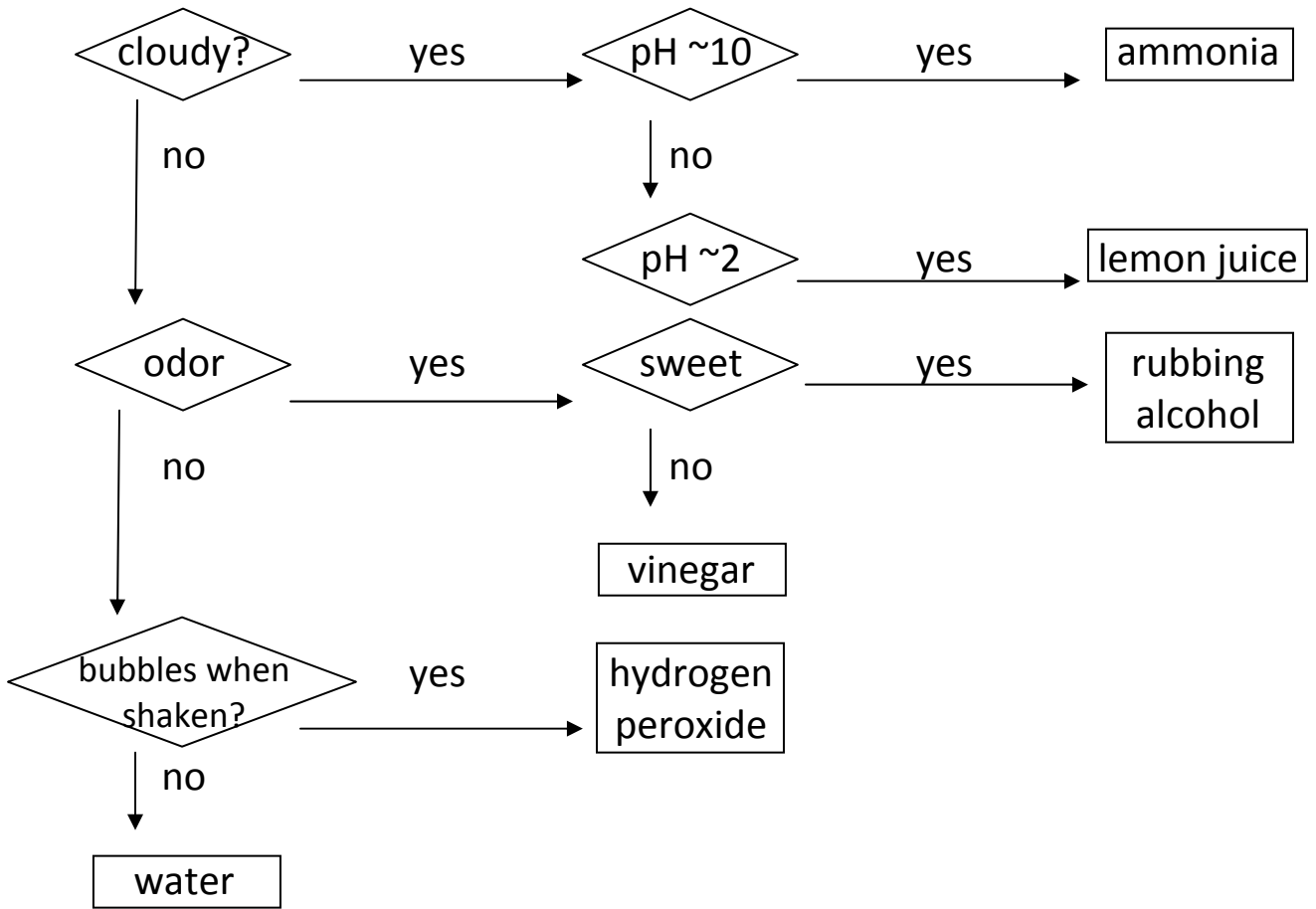Solvent Front

D_2

D_1

Start

5

Liquids

How does one identify a liquid? The answer is simple, we observe, smell, and measure pH. For this event there are only six liquids that we must be able to identify. They are water, ammonia, hydrogen peroxide, lemon juice, rubbing alcohol, and vinegar.

The first test we will do is to observe the solutions. Some of the solutions will all look the same at first. But if you look closely you will notice a difference. Shake all of the liquid vials and see what happens.

The second test we will do is smell. This is an easy test and is one of the best for identifying unknowns. This can be dangerous, so we don't put the chemical right under our nose and inhale. Instead we hold the container a few inches in front of our nose, and bring our hand toward our nose passing the hand over the top of the open container. This procedure is called wafting.

The last test we do is test the pH of the liquids. We do this by dipping a piece of pH paper into a small sample of the liquid, and then comparing the new color of the pH paper to the chart on the side of the pH paper container.

liquid	observation	odor	pH
water			
ammonia			
hydrogen peroxide			
lemon juice			
rubbing alcohol			
vinegar			

```
cloudy? ──yes──▶ pH ~10 ──yes──▶ ammonia
   │                 │
   no                no
   │                 ▼
   │              pH ~2 ──────yes──────▶ lemon juice
   ▼                 
 odor ───yes──▶ sweet ──yes──▶ rubbing alcohol
   │                 │
   no                no
   │                 ▼
   ▼              vinegar
bubbles when ──yes──▶ hydrogen peroxide
shaken?
   │
   no
   ▼
 water
```

DNA

What is DNA? DNA is the molecule that holds your genetic code. Everyone has their one DNA sequence, except identical twins. It is a very long and complex molecule. Lucky for you all you have to be able to do is compare pictures of the suspects' DNA to DNA found at the crime scene.
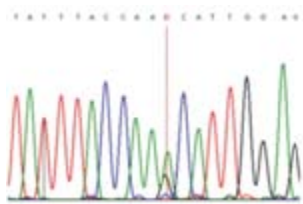
There are two different types of tests results for DNA that you might be shown: chromatograms/electropherograms and electrophoresis results. In order for chromatograms to be a match all of the peaks must match up, as well as the DNA sequence at the top (if shown). For electrophoresis to show a match all of the bars of DNA must be the same distance from the starting well and have the same thickness

DNA sequence

Starting Well

Bar

Electrophoresis

Chromatogram
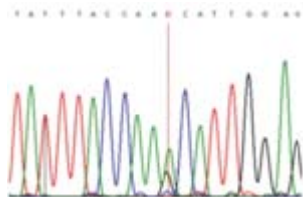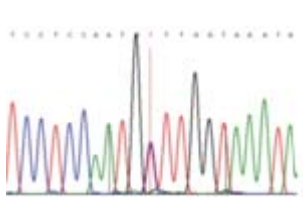
Peak
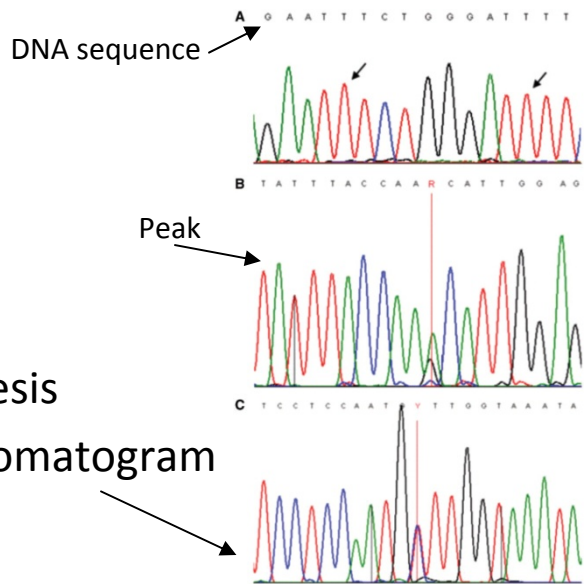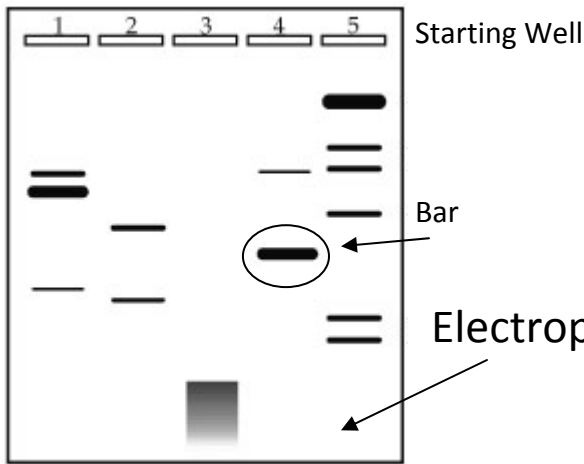
Practice:

Decide who the DNA found at the crime scene belongs to!

Crime Scene

Suspect A   Suspect B

Answer: _____

Crime Scene	Suspect A	Suspect B

Answer: _____

Plastics

In this event, you will be asked to identify plastics. The best way to do this is with sink/float tests. If the plastic is denser than the solvent that you put it in, it will sink, but if it is less dense then it will float. If you have the density of the solvent, and the density of the plastic you can determine if it should float or sink.

Name	Water (1.0g/ml)	70% Alcohol (0.93g/ml)	Corn Oil (.917g/ml)	10% NaCl (1.07g/ml)	25% NaCl (1.19g/ml)	Saturated NaCl (1.36g/ml)	Uses
PETE 1 1.37g/ml							water bottles, two liter soda bottles, cooking oil bottles, peanut butter jars
HDPE 2 0.95g/ml							detergent bottles, milk jugs, aspirin and shampoo containers
PVC 3 1.38g/ml							water bottles, salad dressing containers & household cleaner containers
LDPE 4 0.92g/ml							food containers and some yogurt containers
PP 5 0.90g/ml							reusable plastic food containers, yogurt tubs, butter tubs, plastic cups & pill bottles.
PS 6 1.05g/ml							Styrofoam packaging, some plastic beverage cups, flowerpots & yogurt tubs.

Practice:

1) What are the units of density? _____
2) What is the density of water? _____

Will it sink or float?

3) A piece of plastic has a density of 2, and is placed in water: s / f
4) A piece of plastic has a density of .5, and is placed in water: s / f
5) A piece of plastic has a density of 1, and is placed in water:_____

Metals

       During competition, you will be given a set of metals and asked to identify them. Thankfully, there are only six different metals they could be: aluminum, iron, zinc, magnesium, copper and tin. We can identify a metal using it properties. The properties we will use are color/luster, reaction to a magnet, reaction when water is added, and reaction when HCl is added.

metal	color/luster	magnetic	water	HCl
aluminum (Al)				
iron (Fe)				
zinc (Zn)				
magnesium (Mg)				
copper (Cu)				
tin (Sn)				

```
          Yellowish?  ────────────────▶  copper
              │         yes
              │ no
              ▼
          Magnetic?   ────────────────▶  iron
              │         yes
              │ no
              ▼
        React w/ water ───────────────▶  magnesium
              │         yes
              │ no
              ▼
        React w/ acid ──────────▶  fast?  ──────────▶  zinc
              │         yes         │        yes
              │ no                  │ no
              ▼                     ▼
            tin                 aluminum
```
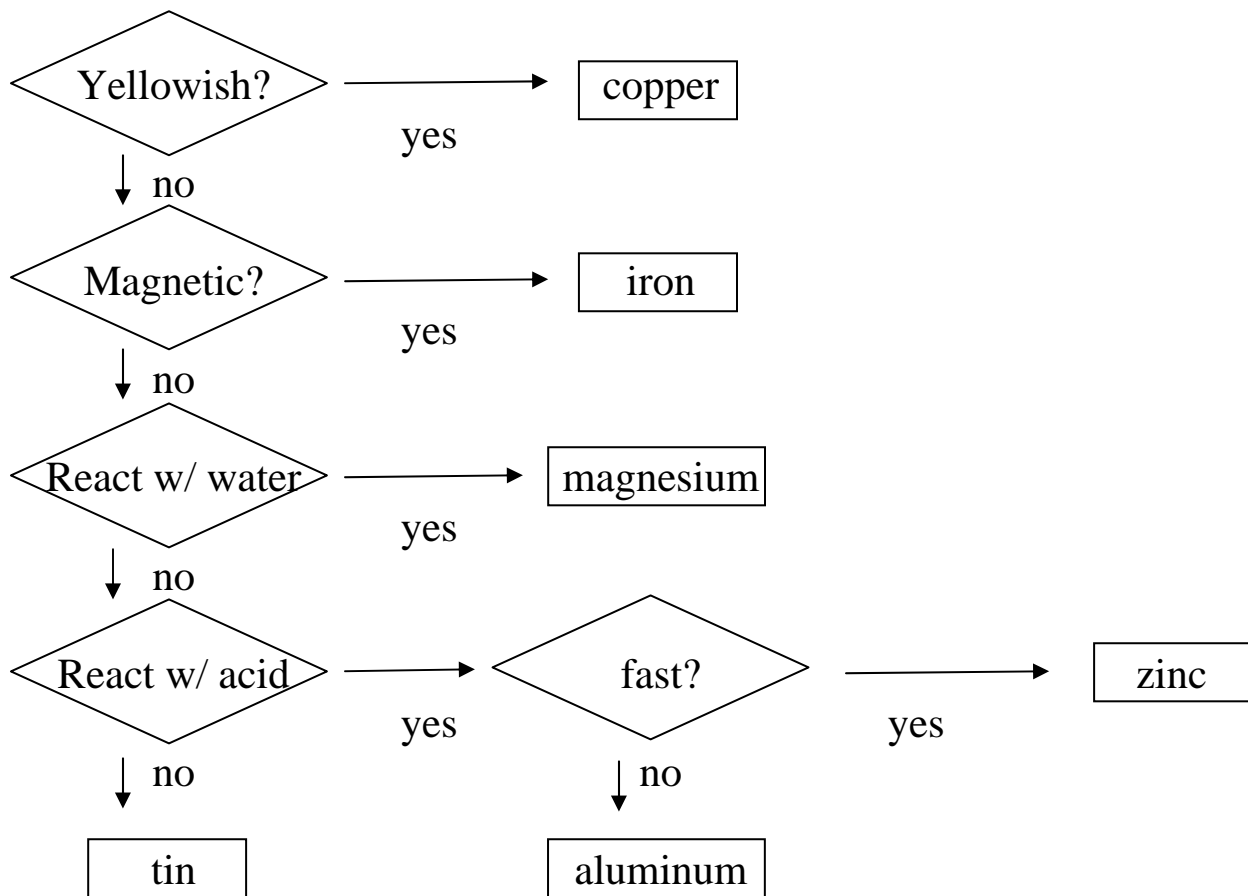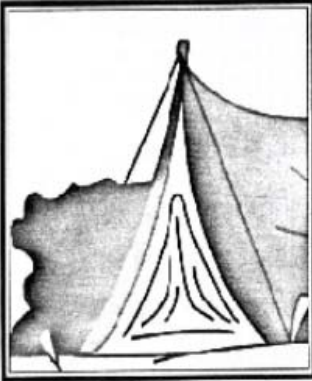
Fingerprinting

You have probably heard that everyone has different fingerprints. But there are certain patterns that fingerprints display. The fingerprints are divided up into 3 basic types, and then one type has a couple of different categories. The first thing we will learn is to identify the different types of fingerprints. Then we will learn to create fingerprint impressions. We will then identify our fingerprint types. Then we will take different fingerprints taken from a "crime scene" and see if we can identify any of the suspects fingerprints as being at the crime scene.

The 3 basic types of fingerprints are whorl, loop, and arch. The arch is further broken up into plain arch and tented arch. The next few diagrams are examples of these types as well as instructions on how to recognize them. These are all blown up larger than "real life" so that you can see the differences.

TENTED ARCH
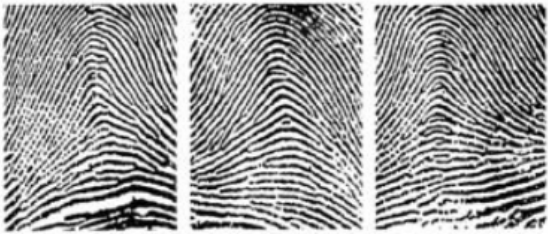
Camping Tent Analogy

Look for a camping tent formation in the center of the pattern.

Ridges rise in the center, pointing upward or forming a triangle

PLAIN ARCH

Road Test Analogy

Ride a bicycle across the hill without getting a flat tire.

Ridges start from both sides and smoothly rise in the center.
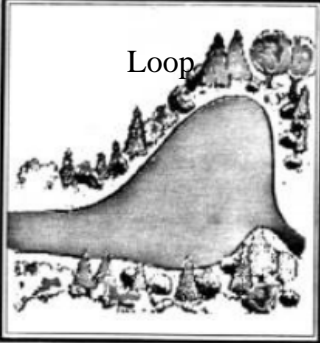
WHORL
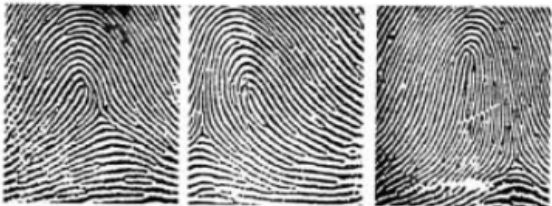
Target Analogy

Look for a target in the center of the pattern.

Ridges appear to circle, spin, whirl or spiral.

Loop

Lake Analogy

Look for a river flowing into what looks like a lake formation.

Ridges start on one side, curve and return to the same side.

Or another way to look at it is to look at delta's

WHORL   LOOP   ARCH
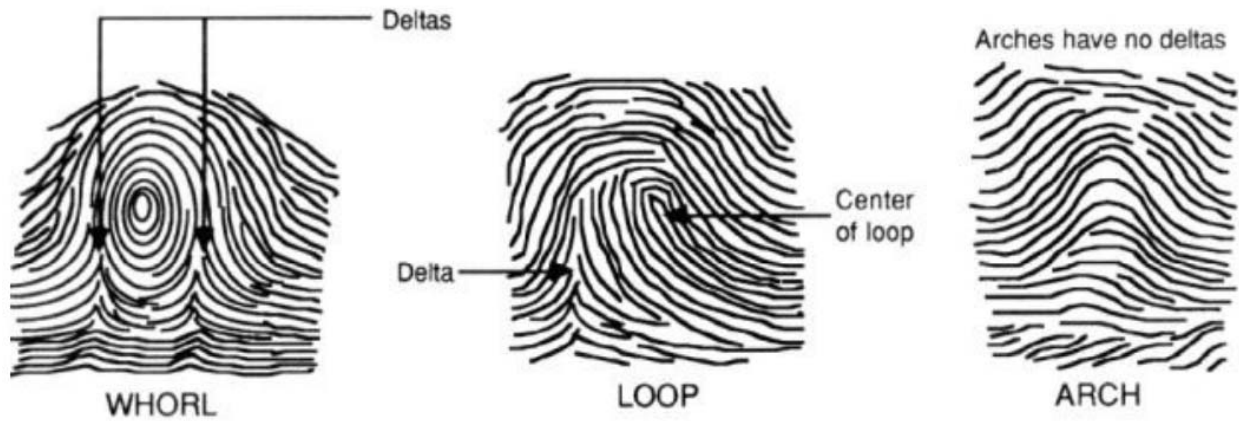
This last set is for you to practice what you have learned. You should identify 2 tented arch fingerprints, 3 plain arch 3 whorl, & 2 loop. Can you figure out which is which? Label the pictures.

Soil

It can truly be said that this is the part of Crime Busters where you get "dig up some dirt" on people. Soil lodged in the soles of someone's shoes can be matched to soil found at the crime scene. Soil is studied by examining its color, and what types of rocks are found in it.

There are four major types of soil: clay, silt, sand and loam, but a soil sample can be any combination of the three. Clay soil is composed of very fine (small) particles; less than .0004 cm. Silt is composed of small particles (between .0004 cm and .006 cm), that are bigger than the particles in clay. Sand is composed of medium sized particles; between .006 cm and .2 cm. Loam soil is composed of nutrients and decaying matter. It is composed of relatively equal parts clay, silt, and sand; the particle size varies. The type of soil tells us relatively how big the particles are in the soil.

The color of the soil sample can tell us what types of compounds are in it. If the soil is white or light grey it contains silica. If it is black, dark brown, or dark gray then it contains humus or decaying plant and animal matter. If it is reddish brown it contains iron compounds.

During competitions you may be given the composition of soil found at the crime scene, and asked to determine if it implicates any of the suspects. We do this by comparing the soil found at the crime scene with soil found on the suspects. If the soils match, the suspect was probably at the crime scene.

Practice:

Suspect A: soil found on the bottom of Suspect A's shoes is reddish, and has very fine particles.
1) What does this soil contain?_____
2) What type of soil is this?_____

Suspect B: soil found on the bottom of Suspect B's shoes is light grey, and has small particles.
3) What does this soil contain?_____
4) What type of soil is this?_____

Suspect C: soil found on the bottom of Suspect C's shoes is black, and contains various size particles.
5) What does this soil contain?_____
6) What type of soil is this?_____

Crime Scene: soil found at the crime scene is reddish, and has various sized particles.
7) Which suspect(s) could have been at the crime scene? How do you know?_____
_____
_____

Shoeprints & Tire Tracks

       Shoeprints and tire tracks are the marks left when people walk or wheeled vehicles drive on a surface. In this event, we will be comparing and matching shoeprints and tire tracks, as well as determining direction and speed of travel.

       For shoeprints, the toe of the shoe usually points in the direction the wearer of the shoes is going, while the heel of the shoe points in the direction the person came from. If the person if traveling fast, a.k.a. running, their shoeprints are heavy in the toe, light in the sole, but if they are going slower, a.k.a. walking, then their shoeprints are deep and heavy in the sole.

       Fore tire tracks, the wheeled vehicle is going forwards if the tracks all line up (there are only two tracks for a car, one for a bicycle); if the tracks are shaky and do not line up the vehicle is going backwards. Braking marks start out lighter, and get darker, whereas acceleration marks start out heavy and get lighter as traction is acquired.

Practice: Match the track or print to the tire or shoe it came from.

15
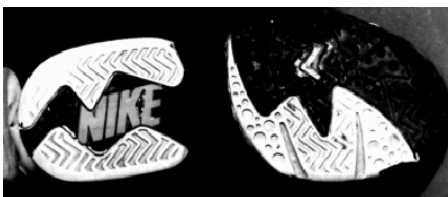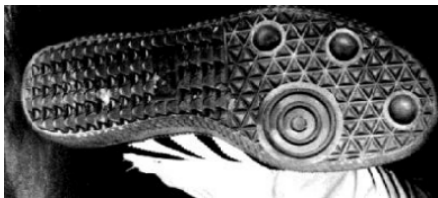
Hair

What are the differences between human, dog, and cat hair? Cat hair is usually finer than human hair or dog hair. Dog hair can be of two different kinds. The outer coat is generally very course and often straight. The undercoat is often fine and can be very curly. In human hair, the color of the hair can make a difference too. Generally speaking, dark hair is thicker than blond hair and red hair is the finest.

Human   Cat   Dog

We can identify hair by looking at it under a microscope. Identify the hair samples by preparing a slide of each sample, and looking at it under the microscope. Use the characteristics above to identify if it is human, dog, or cat.

Another useful tool in identifying hair is the medullary index of the sample. Medullary index is the overall diameter of the hair divided by the diameter of the medulla. The medulla is the inside part of the hair that is usually contains the pigment that gives the hair its color. Cat hair has a medullary index <1/2, dog hair has a medullary index >1/2, and human hair has a medullary index <1/3.

Diameter of whole hair   Diameter of medulla
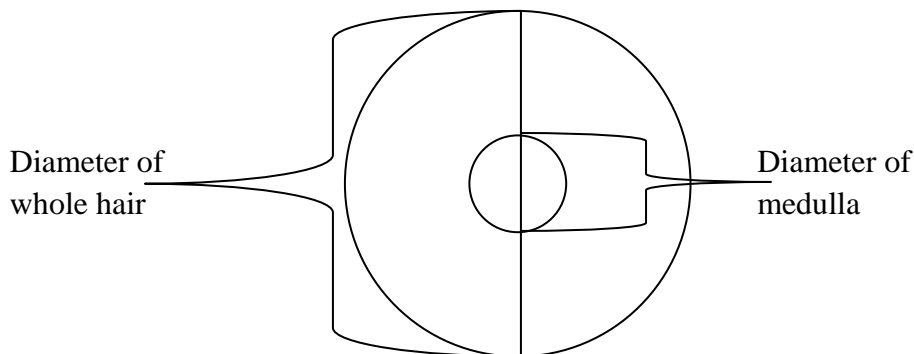
FUN FACT: If the part of the hair around the medulla is colored then that piece of hair was dyed.

Practice:

Identify if the hair is human, dog, or cat:

1) A piece of red hair was found on a blond haired man who has a tabby cat:_____

2) A forensic scientist determines the medullary index of a piece of hair found at a crime scene to be 3/4:_____

Thinking Question A piece of hair is completely green. What is special about this piece of hair? Is it likely human, dog, or cat, and why?_____
_____

Powders

During competition, you will be given a series of powders and asked to identify them. This is relatively easy if you know what tests to perform. The best ones to use are shape (what the powder/crystal looks like), pH (use pH paper), solubility in water (does it dissolve), reaction to HCl (what happens when HCl is added), and reaction to I_2 (what happens when I_2 is added).

Substance	Shape	pH	Water	HCl	I_2	Other
Alka-Seltzer						
Baking Soda						
Calcium Carbonate						
Cornstarch						
Flour						
Gelatin						
Gypsum						
Salt						
Sand						
Sodium Acetate						
Sugar						
Vitamin C						
Yeast						

```
Powder? ──yes──▶ Fizz in H₂O ──yes──────────────▶ ┌──────────┐
                                                   │  Alka-   │
                                                   │ Seltzer  │
                                                   └──────────┘
  │                    │
  no                   no
  │                    ▼
  │              React w/ ──yes──▶ Soluble in ──yes──▶ ┌────────┐
  │               HCl               H₂O                │ Baking │
  │                                                     │  Soda  │
  │                                                     └────────┘
  │                    │
  │                    no
  │                    ▼
  │              Turn blue ──yes──▶ pH ~8 ──yes──▶ ┌───────────┐
  │               w/ I₂?                           │ Cornstarch│
  │                                                └───────────┘
  │                    │              │
  │                    no             no
  │                    ▼              ▼
  │              ┌────────┐      ┌────────┐
  │              │ Gypsum │      │ Flour  │
  │              └────────┘      └────────┘
  │
  ▼
Crystalline? ──yes──▶ Soluble in ──yes──▶ Jelly-like? ──yes──▶ ┌─────────┐
                       H₂O                                      │ Gelatin │
                                                                └─────────┘
  │                    │                     │
  no                   no                    no
  ▼                    ▼                     ▼
┌───────┐          ┌──────┐            pH ~8 ──yes──▶ ┌──────────┐
│ Yeast │          │ Sand │                           │  Sodium  │
└───────┘          └──────┘                           │  Acetate │
                                                       └──────────┘
                                          │
                                          no
                                          ▼
                                    Turns I₂ ──yes──▶ ┌───────────┐
                                     clear?           │ Vitamin C │
                                                       └───────────┘
                                          │
                                          no
                                          ▼
                                    Regular ──yes──▶ ┌──────┐
                                    shaped            │ Salt │
                                    crystals?         └──────┘
                                          │
                                          no
                                          ▼
                                    ┌───────┐
                                    │ Sugar │
                                    └───────┘
```