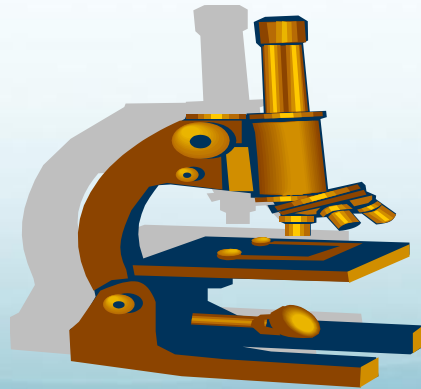


# Forensics



# Safety

- Students must wear:
  - Closed-toed shoes with socks
  - Pants or skirts that come to the ankles
  - Lab coat with long sleeves that reaches wrists and the knees or Long sleeved shirt that reaches wrists with a chemical apron that reaches the knees.
  - Skin should be covered from neck down to the wrist and toes
  - Indirect vent or unvented chemical splash proof goggles.
  - Gloves are optional but if a host requires a specific type they must notify teams
  - Long hair must be tied back

# Students Can Bring

- Test Tubes (brushes & racks) or any devices to perform tests
- Eye droppers
- Funnel(s) and filter paper
- pH or litmus paper
- Spatulas, plastic spoons, stirring rods
- 9-volt Battery Conductivity tester
- Thermometer
- Flame test equipment (nichrome wire/cobalt blue glass)
- Slides and covers

# Students Can Bring

- Hand Lens
- Writing Instrument
- Pencil and ruler for chromatography
- Paper towels
- Metal tongs
- Each team may bring 5 pages 2-sided, containing information in any form and from any source inserted into the rings of the binder (sheet protectors are permitted)
- Two calculators of any type dedicated to computation

# Supervisors will provide

- Unknowns
- Iodine reagent
- 2M HCl
- 2M NaOH
- Benedicts Solution
- Hot water bath
- Bunsen burner or equivalent
- Waste container
- Chromatography Materials
- Wash bottle with distilled water

# Supervisors May Provide

- Microscope
- Probes
- Candle & matches for fibers
- Differential density solutions or other method to determine density of polymers
- Reagents to perform other tests

# Main Focus

- ❖ Qualitative Analysis (20%)
- ❖ Polymers, Fibers, Hair (20%)
- ❖ Chromatography/Spectroscopy (15%)
- ❖ Crime Scene Physical Evidence (15%)
- ❖ Analysis of Crime (30%)

# How To Prepare Students

- Have students develop a dichotomous key for identifying powders
- Practice identifying powders in as short a time as possible.
- Practice identifying plastics
- Practice identifying hairs (only human, bat, cow, squirrel & horse possible)
- Practice identifying fibers (cotton, wool, silk, linen, nylon, spandex, polyester)



# How to Prepare Students

- Practice doing pen chromatograms/doing  $R_f$
- Practice doing juice chromatograms/doing  $R_f$
- Practice doing TLC (Thin Layer Chromatography) /doing  $R_f$
- Practice identifying masses from mass specs
- Practice identifying fingerprints-primary and secondary structure as well as common fingerprint development techniques. Should know the 8 specific fingerprint patterns.

# How to Prepare Students

- Practice matching DNA chromatograms & electropherograms and how DNA is copied
- Glass analysis including index of refraction
- Entomology know life cycle of the blow fly
- Practice matching shoes & tires to their tracks and soil composition
- Practice blood typing
- Analyze spatter to determine angle & velocity
- Compare seeds and pollen
- Matching bullet striations

# Crime

- Step one – read over crime
- Best to divide and conquer
- One partner starts on chromatography
- One partner starts on Qualitative Analysis
- Partner finishes chromatography & starts polymers
- Should finish in about 30 minutes and have remaining time to analyze.

# Qualitative Analysis Powders

$\text{NaC}_2\text{H}_3\text{O}_2$ Sodium Acetate	$\text{NaCl}$ Sodium Chloride	$\text{NaHCO}_3$ Sodium Bicarbonate
$\text{Na}_2\text{CO}_3$ Sodium Carbonate	$\text{LiCl}$ Lithium Chloride	$\text{KCl}$ Potassium Chloride
$\text{Ca}(\text{NO}_3)_2$ Calcium Nitrate	$\text{CaSO}_4$ Calcium Sulfate	$\text{CaCO}_3$ Calcium Carbonate
Cornstarch	Sucrose	Glucose
$\text{MgSO}_4$ Magnesium Sulfate	$\text{H}_3\text{BO}_3$ Boric Acid	$\text{NH}_4\text{Cl}$ Ammonium Chloride

$\text{NaC}_2\text{H}_3\text{O}_2$ ,  $\text{NaCl}$ ,  $\text{NaHCO}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{LiCl}$ ,  $\text{KCl}$ ,  $\text{Ca}(\text{NO}_3)_2$ ,  $\text{CaSO}_4$ ,  $\text{CaCO}_3$ ,  
Cornstarch, Glucose, Sucrose,  $\text{MgSO}_4$ ,  $\text{H}_3\text{BO}_3$ ,  $\text{NH}_4\text{Cl}$

Add water

$\text{CaSO}_4$ ,  $\text{CaCO}_3$ ,  
Cornstarch

Insoluble

$\text{NaC}_2\text{H}_3\text{O}_2$ ,  $\text{NaCl}$ ,  $\text{NaHCO}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{LiCl}$ ,  $\text{KCl}$ ,  
 $\text{Ca}(\text{NO}_3)_2$ , Glucose, Sucrose,  $\text{MgSO}_4$ ,  $\text{H}_3\text{BO}_3$ ,  $\text{NH}_4\text{Cl}$

Soluble

pH paper

Acid  
 $\text{NH}_4\text{Cl}$ ,  $\text{H}_3\text{BO}_3$

Strong Base  
 $\text{Na}_2\text{CO}_3$

Weak Base  
 $\text{NaC}_2\text{H}_3\text{O}_2$ ,  
 $\text{NaHCO}_3$

No Reaction  
 $\text{NaCl}$ ,  $\text{LiCl}$ ,  $\text{KCl}$ ,  
 $\text{Ca}(\text{NO}_3)_2$ ,  
 $\text{MgSO}_4$ , Glucose,  
Sucrose

Add NaOH

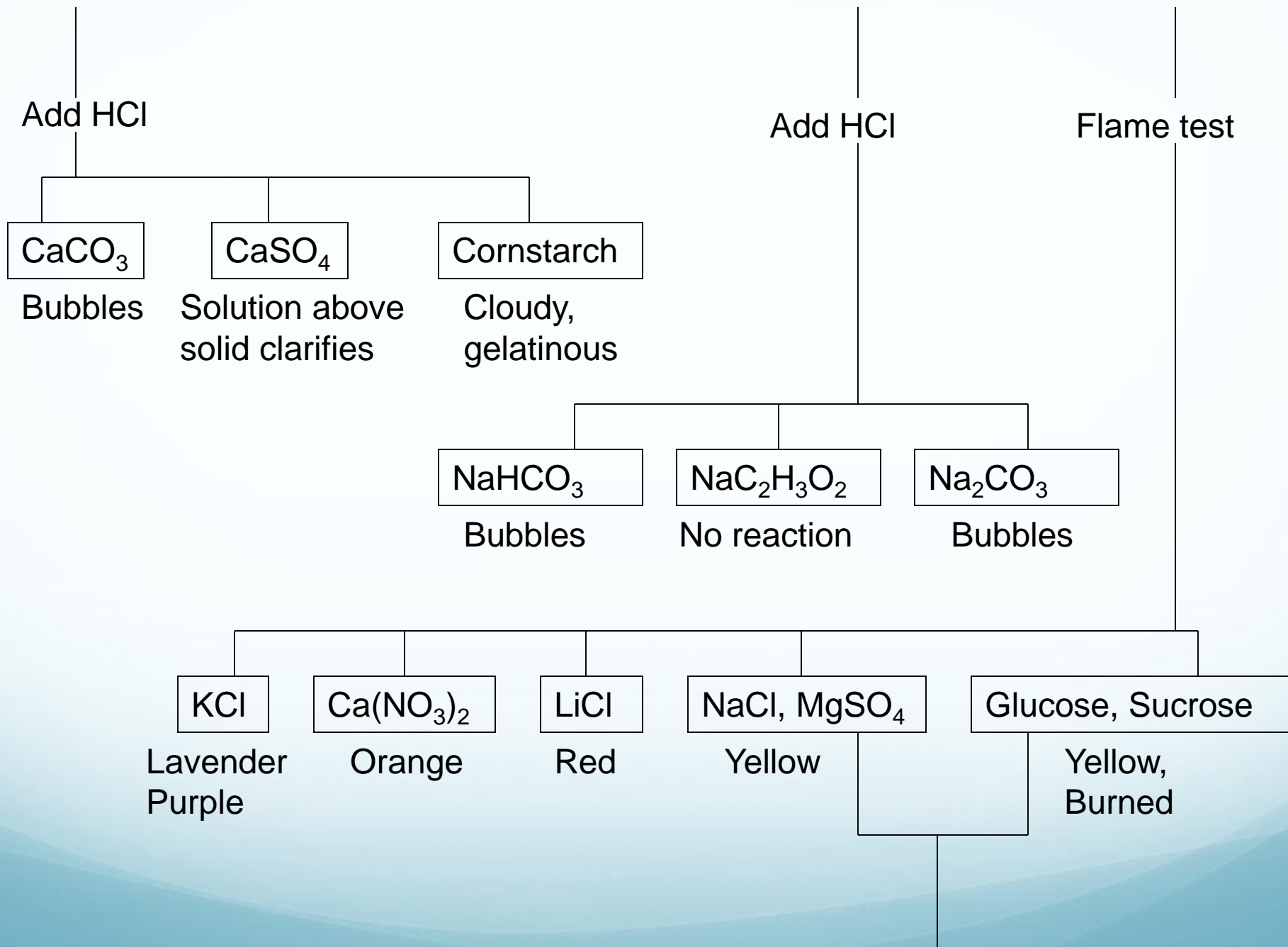
$\text{NH}_4\text{Cl}$

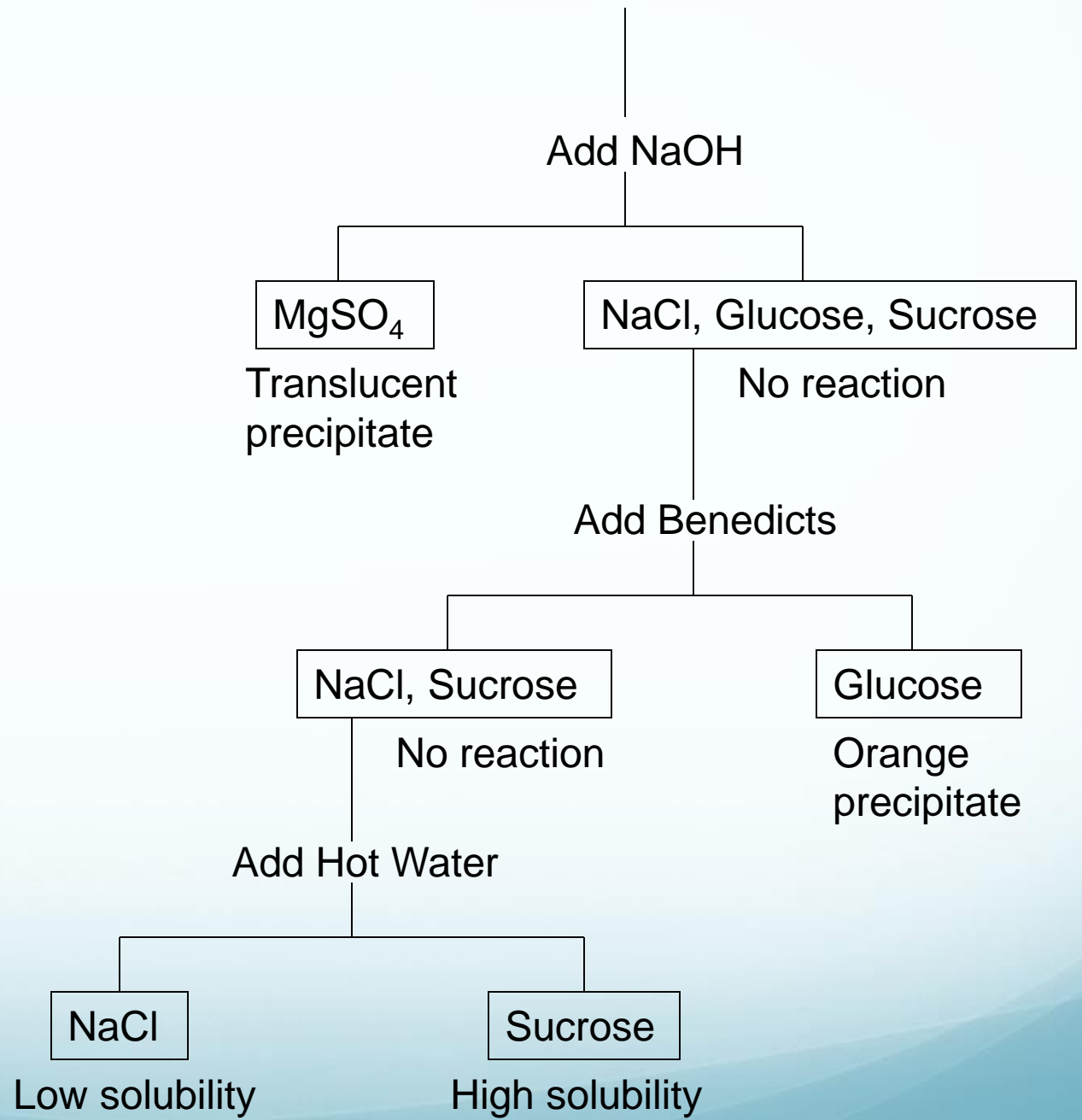
$\text{NH}_3$  odor

$\text{H}_3\text{BO}_3$

No odor

Optional





# Polymers

Name	Densities/SP. GR.
• Polyvinylchloride	1.38
• Polypropylene	0.90
• Polycarbonate	1.20
• High Density polyethylene	0.95
• Low Density polyethylene	0.92
• Polystyrene	1.05
• Polyethyleneterephthalate	1.37
• Polymethylmethacrylate	1.16

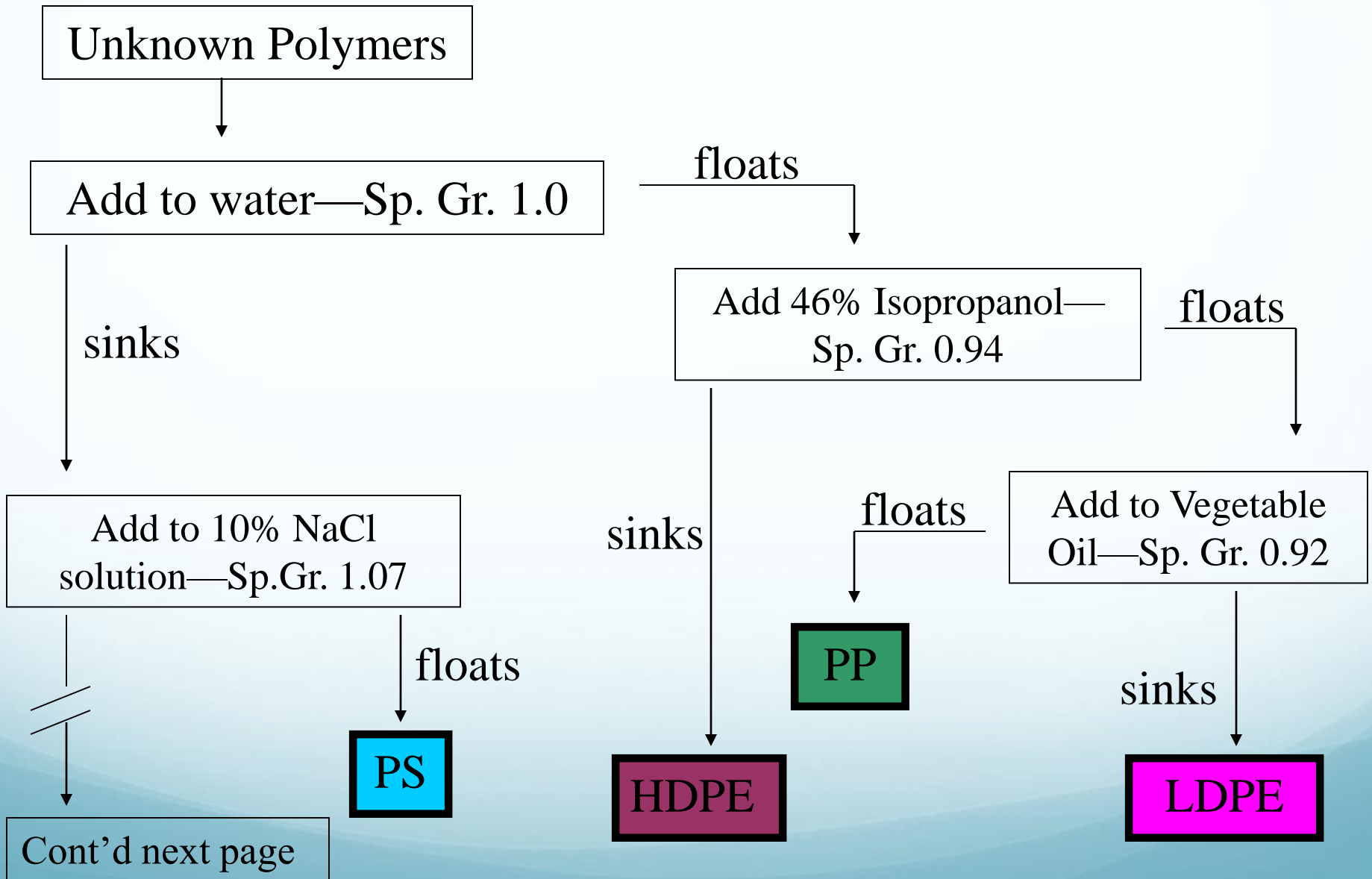
Values are approximate

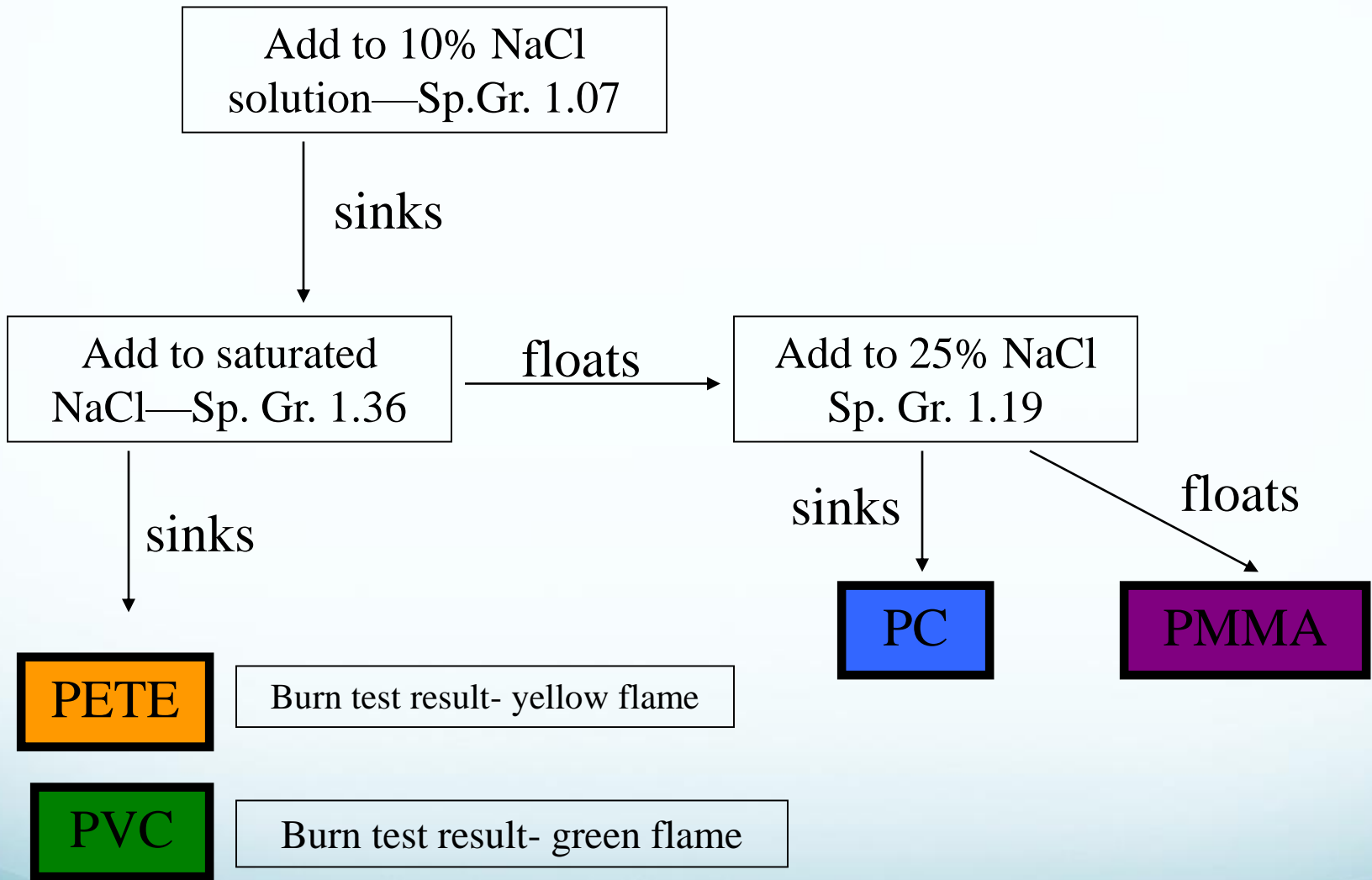


# Densities of Common Solvents

- Water 1.0g/ml
- 10% Salt Water 1.07
- 20% “ “ 1.15
- 25% “ “ 1.19
- Saturated NaCl 1.36
- 50% Ethanol/water 0.94
- 70% Isopropanol 0.93
- 0.918
- Mazola Oil

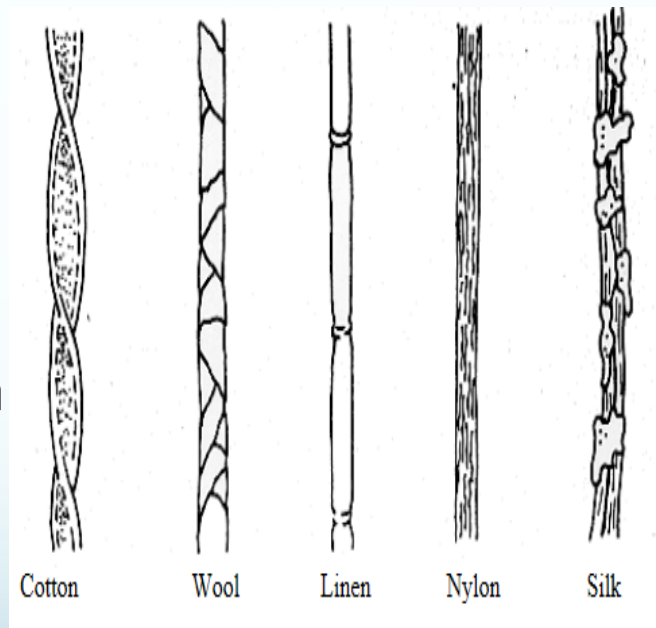
# Polymer Scheme





# Fiber Analysis

- Need to know the difference between Wool, Silk, Cotton, Linen, and Nylon, Spandex, and Polyester fibers
- Easiest to identify with burn test
  - Animal shrivel in heat
    - Wool shorter fibers than silk
    - Wool smells like burning hair
  - Vegetable burn
    - Cotton shorter fibers than Linen
  - Synthetic melts
    - Spandex stretches



# Hair Analysis

- Only allowed to use Human, bat, cow, squirrel, and horse
- Best identified by looking at microscope.
- Horse very thick, coarse and round.
- Human hair thick, no distinct cuticle
  - Can be flat or round, generally no medulla
- Cow coarse diameter, abundance of ovoid bodies & medullae continues into elongated root area
- Squirrel hair is thin with a pointed tip & uniform body often banded
- Bat hair has crown like scale pattern resembling a stack of paper cups

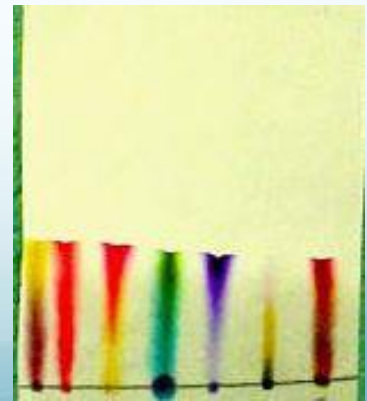
# Chromatography

- Used to separate mixtures into components
- Uses stationary paper or coffee filter or TLC paper and mobile water or solvent like alcohol
- Draw a line ~ 2 cm from bottom in pencil
- Spot on line. Use toothpick for liquids.
- Use pencil to label at top above spot.
- Put bottom only of paper in water

# Chromatography Continued

- Wait until water moves up ~ 3/4ths of paper
- Draw line with pencil where water or solvent has moved to
- Make dot @ middle of each distinct separated molecule
- Measure from bottom line to each molecule mark
- Measure from bottom to solvent line
- $R_f$  (Retardation Factor)=

$$\frac{\text{migration distance of Substance}}{\text{migration distance of Solvent}}$$



# Fingerprints

- Need to know 8 specific patterns
  - Plain Arch
  - Tented Arch
  - Radial Loop
  - Ulnar Loop
  - Plain Whorl
  - Central Pocket Whorl
  - Accidental Whorl
  - Double Loop Whorl
  - Accidental



Plain Whorl

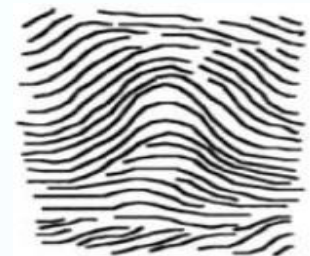


Central Pocket Loop

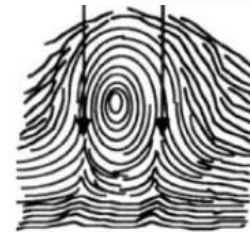


LOOP

Center of loop



ARCH



WHORL



7 Target Whorl  
Concentric Circles



ACCIDENTAL



5. Simple Arch



# Fingerprinting

- Emphasis is on understanding the chemistry of how the fingerprinting works
- Body gives off oils and salts that the chemicals adhere to.
- Some methods of fingerprinting development are:
  - Dusting
  - Iodine fuming
  - Ninhydrin
  - Cyanoacrylate fuming

# DNA

- Need to understand chemistry behind method of reproducing enough DNA for analysis (PCR).
- Easy to make electropherograms
  - Make rectangle with drawing program
  - Use spray tool to spray in different width, density lines at various distances.
- Students should understand basic structure of DNA and how DNA is copied



# Index of Refraction

- Light travels at different speeds through different materials.
- Light travels slower through denser media
- Light bends when it goes from one medium to another.
- The index of refraction is the ratio of the sine of the angle the light makes coming in compared to the sine of the angle in the new media

$$\text{Index of Refraction (n)} = \frac{\text{speed of light}}{\text{speed of light through material}}$$

- Objects disappear when put in a liquid with the same index of refraction

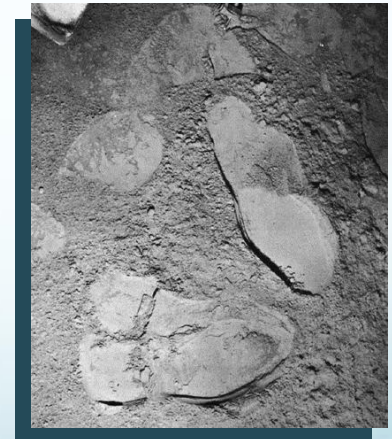
# Entomology

- Depends on predictable life cycle of flies.
- Depends on temperature body experiences after death.
- It is assumed that flies will lay eggs immediately after death
- Eggs hatch in ~1.5 days as maggots
- Maggots pupate in ~ 5 days
- Flies immerge in~ 15 days



# Tracks

- Use picture matching
- Bike tracks easy to make
  - Have cookie sheet filled with sand
  - Take a picture of tire, run through sand, and take a picture of track.
- For footprints photo bottom of shoe
  - Stomp in cookie sheet of flour
  - Stomp on black construction paper
  - Photograph paper



# Soil Analysis

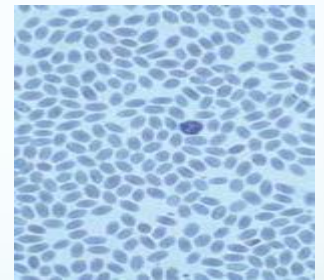
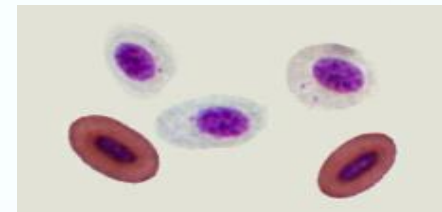
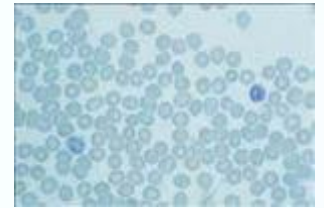
- Sand, Silt, Clay, and Loam
- Students allowed to touch soil to analyze
  - Sand-large grains, does not ball in hand
  - Clay-very small grains, forms ribbons in fingers
  - Silt-medium grains, forms ball, but falls apart
  - Loam-lots of organic material, black

# Seeds and Pollen

- Mostly useful if found away from an area naturally found
- Can be useful if embedded in hair or fur
- Small seeds are generally windblown, but can get caught in clothing and hair
- Seed placement can also be very useful in placing time of a crime.
- Pollen very useful because pollen is very species and subspecies specific.
- Pollen needs to be compared under a microscope

# Blood Serology

- Student should recognize
  - human blood cells (round, no nuclei 6-8/ microns),
  - avian blood cells (elliptical, single nucleus, 6-12 microns)
  - mammalian blood cells (no nuclei, 5.5-7.5 microns, can be elliptical or round)
  - reptile/amphibian blood cells (multiple nuclei).





# Blood Typing

- Can not use real blood
- Type A has A antigens & B antibodies  
Type B has B antigens & A antibodies  
Type O has No antigens & both antibodies  
Type AB has Both A and B Antigens
- Know RH Factor and what it means in blood typing
- Blood typing works on which sugars on cell walls, A,B & O
- Fake blood can be made of several recipes. Check on-line for recipes
- Website to practice Blood Typing:  
<http://www.nobelprize.org/educational/medicine/landsteiner/index-oldgame.html>

# Spatters

- Should know if strait drop or angle
- Should know if spatter is high, medium or low velocity
- Blood Stain types: Transfer, Passive, Projected
- Angle of impact is  $\sin(a) = w/l$ , where a is angle of impact, w is width of ellipse & l is length of ellipse
- Point of origin found by drawing lines along lengths of drops
- Start with red finger paint, then mix in blue and green until correct shade
- Then dilute with water slowly until proper consistency.
- Students should put in eye dropper or use paint brush and drop straight down @ 1 cm, 10 cm. 20 cm, etc.

# Bullets

- This is mostly picture matching
- The idea is to match the scratch pattern on two bullets to determine if they have been fired from the same gun.
- The scratches are a result of the machining done when the gun was made.
- In real crimes this is done with a special microscope that allows the technician to see both bullets at the same time.

# The Crime

- Now we use all of the results to solve the crime.
- Logic is used.
- Use the evidence and that is used to solve the crime
- The correct answer may be one of the suspects, more than one of the suspects, all of the suspects, or none of the suspects.
- Use all the evidence to determine the criminal(s) and to exonerate the other suspects.
- **BE SURE TO LEAVE ENOUGH TIME TO COMPLETE THE ANALYSIS!!**

# Resources

- National Science Olympiad Website  
<https://www.soinc.org/forensics-c>
- For Student Tests  
<https://scioly.org/wiki/index.php/Forensics>
- Quizlet  
<https://quizlet.com/19852385/science-olympiad-forensics-flash-cards/>

# Resources Continued

- **How to do flame tests:**

- <http://www.youtube.com/watch?v=oJcD0Tzr5Cw>
- [http://www.youtube.com/watch?v=q\\_DhUTVTqeg&feature=related](http://www.youtube.com/watch?v=q_DhUTVTqeg&feature=related)
- <http://www.youtube.com/watch?v=vFx86jkzygY&feature=related>

- **Source for mass specs:**

- [http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/cre\\_index.cgi](http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/cre_index.cgi)
- <http://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/spectrpy/massspec/masspec1.htm>