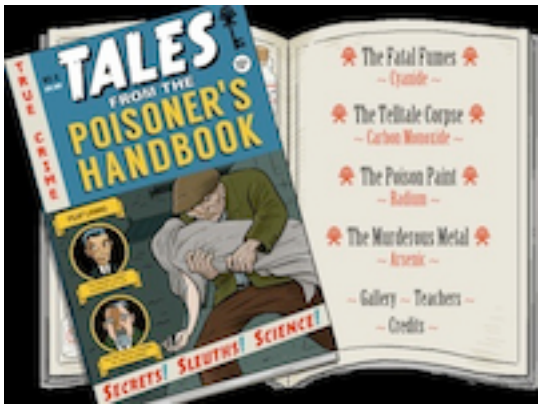
The Poisoner's Handbook

Teacher's Guide



Working with forensic science instructor Rich Fox, (http://www.boston.k12.ma.us/charlestown/forensics.html) American Experience created four simulation experiments designed to mimic forensic science tests used in early 20th-century New York City to detect poisoning.

In the interactive graphic novel *Tales From the Poisoner's Handbook*, (www.pbs.org/wgbh/americanexperience/features/interactive/poisoners-tales) follow former forensic chemist Alexander Gettler and chief medical examiner Dr. Charles Norris as they track the visual evidence and follow the chemical trails in four real-world case studies of **cyanide**, **carbon monoxide**, **radium** and **arsenic** poisoning. Then use the non-toxic simulations below to bring the cases to life in the classroom!

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Simulating the Prussian Blue Cyanide Test

In the 1920s, a common test for cyanide was the Prussian Blue Test in which thick sections of autopsy tissue were placed in a 5% solution of caustic potash for about a minute, then transferred to a solution containing 2.5% of ferrous sulfate, and 1% of ferric chloride, and heated to 60 degrees Celsius. After 10 minutes, they were placed in a mixture of one part hydrochloric acid to six parts water. When cyanide was present, the sections showed the Prussian Blue reaction in 10 to 15 minutes.

However, the brilliant blue in the cyanide test can be recreated using simple household chemicals and certainly without the use of cyanide! Cabbage juice works as a universal indicator and will turn a brilliant blue in the presence of a base such as household ammonia. In order to add some authenticity to the demonstration, a small piece of chicken liver can serve as our "Autopsy Tissue."

Materials:

- Head of red cabbage
- Medium-size bowl
- Grater
- Cold water
- Strainer
- Test tube
- Household ammonia
- Chicken liver

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Procedure:

1. To prepare your cabbage juice, grate some red cabbage into a medium-size bowl.
2. Cover the cabbage with cold water and let it sit for 45 minutes.
3. Strain the juice into a plastic container.
4. Place a small piece of chicken liver ("autopsy tissue") into the test tube.
5. Use a dropper to transfer ammonia into the test tube until the tissue is submerged.
6. Use another dropper to add drops of cabbage juice to the tissue solution, until a dark blue color appears.
7. The appearance of dark blue confirms the presence of cyanide.

Disposal:

These chemicals will require no special disposal procedures and can be poured down the drain.

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Simulating the Pink Carbon Monoxide Test

When carbon monoxide reacts with human blood it forms carboxyhemoglobin, which can sometimes cause a bright red (or pinkish) coloring in the tissues and blood. A visual inspection of a carbon monoxide victim is not a reliable test for carbon monoxide poisoning because many factors can effect the pink/red color change. Modern labs use a spectrophotometric analysis to measure carboxyhemoglobin levels, but this instrumentation was not available in the 1920s. Phenolphthalein turns pink in the presence of a base. The following procedure will help produce the pinkish color of carbon monoxide poisoning without the use of real human blood.

Materials:

- Porcelain evaporating dish
- Red food coloring
- 10 ml water
- 10 ml graduated cylinder
- 1% phenolphthalein solution
- 0.1 M sodium hydroxide (NaOH) first choice; (or household ammonia, which is more accessible, but it smells bad)
- Test tube
- Eye-dropper
- Glass stirring rod

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Procedure:

1. Measure 10 ml of water using graduated cylinder.
2. Transfer water into clean test tube.
3. Add red food coloring until solution looks like dark red blood.
4. Place four drops of .1 M sodium hydroxide or dilute ammonia into fake "blood."
5. Transfer fake "blood" solution into medium evaporating dish or similar container
6. Add drops of phenolphthalein to fake blood solution and stir with glass rod until it turns a bright pink.

Note: Recipes for phenolphthalein are readily obtainable from the Internet, but it can be inexpensively purchased. (Most science supply sources sell 500 ml for under $10.)

Disposal:
These chemicals will require no special disposal procedures and can be poured down the drain.

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Simulating the Photographic Radium Test Using UV-Sensitive Paper

Since radium is chemically similar to calcium, it has the potential to replace calcium in bones and thus cause great harm. Exposure to radium can cause cancer and other disorders because radium and its decay product radon emit alpha particles upon their decay, which kill and mutate cells. As radium decays, the alpha particles will leave images on photographic paper.
This reaction will recreate the radium photographic chemical test found in *Tales From the Poisoner's Handbook* (www.pbs.org/wgbh/americanexperience/features/interactive/poisoners-tales) and does not actually require radioactive materials! Students can reproduce the ultraviolet-activated chemical reaction used in blueprinting and mimic certain aspects of the photographic process with this blueprinting paper lab. Images produced appear in just minutes and are permanent.

Materials:

- 10 ml ferric nitrate solution Fe (NO_3) 3, 0.10 M
- 10 ml oxalic acid solution, (H_2C_2) 04, 0.15 M
- 10 ml potassium ferricyanide solution, (K_3 Fe (CN) 6, 0.10 M
- 2 pieces corrugated cardboard, at least 8cm square
- Filter paper, 7-cm diameter
- 2 graduated cylinders, 10-ml
- Opaque or translucent plastic bones found at a toy store
- Paper towels
- Stirring rod
- Tongs or forceps
- 2 plastic weighing dishes, 3x3

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Procedure:

Part 1 -- Preparing UV-Sensitive paper

1. Measure 10 ml of 0.10 M ferric nitrate solution and pour it into weighing dish.
2. Measure 10 ml of 0.15 oxalic acid solution. Combine it with the ferric nitrate in the weighing dish and mix well with a stirring rod. This solution (which is now ferric oxalate) will be Solution 1. Set the dish containing Solution 1 aside for use in step 4.
3. Measure 10 ml of 0.10 M potassium ferricyanide solution and pour it into a separate weighing dish. This will be Solution 2.
4. Use a pair of tongs or forceps to soak a piece of filter paper in Solution 1. As soon as it is completely saturated, remove the filter paper and blot it on a paper towel.
5. Take the same piece of filter paper and dip it into Solution 2, turning it over to wet both sides. Remove it and blot it on a paper towel.
6. Place the treated filter paper on a piece of cardboard. Cover it with a second piece of cardboard.

Part 2 -- Developing Images on Treated Paper

1. Locate both a sunny area and a cloudy or shaded area outside.
2. Bring a non-metallic object(s) and the treated filter paper into the shaded area. Remove the top piece of cardboard, and quickly place the object(s) on the paper. (Note: Doing this in the shade helps to block the paper from direct sunlight.)
3. With the object set on the treated paper on the cardboard, move to a sunny area. Set the paper in the sunlight, exposing it to bright, direct sunlight until the paper turns a dark blue color. This step will only take about five minutes, depending on the brightness of the sun.
4. After the paper is developed, remove the object and cover the paper with the top cardboard piece. Bring it indoors (out of the sunlight). Holding the paper with tongs, rinse it under cold water for a few minutes to remove the yellow color of excess iron ions. Rinse until the solution turns clear and until the paper turns a lighter blue.

Disposal:

Oxalic acid and ferric nitrate solutions can be poured down the drain with running water. Potassium ferricyanide solution should be kept in a separate waste container under a fume hood and disposed of by the school's chemical waste team.

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Simulating the Arsenic "Silver Mirror"

The Marsh Test is a method so sensitive that it can be used to detect minute amounts of arsenic in stomach contents. Before it was published in 1836, arsenic was untraceable in the body and thus a popular choice among poisoners. In the Marsh Test, the sample is placed in a flask with arsenic-free zinc and sulfuric acid. Arsine gas forms (as does hydrogen) and passes through a drying tube to a hard glass tube in which it is heated. The arsenic deposits as a "mirror" just beyond the heated area and on any cold surface held in the burning gas emanating from the jet. In this simulation, an aldehyde is oxidized by silver (l) to generate a carboxylic acid and silver metal, which coats the surface of the glass vessel simulating the mirror effect of arsenic.

Materials:

- 0.1 M silver nitrate ($AgNO_3$)
- 0.5 M dextrose
- Conc. nitric acid (NHO_3)
- Conc. ammonium hydroxide (NH_4OH)
- 0.8 M potassium hydroxide (KOH)
- Large test tube/ rubber stopper
- Beaker
- Deionized water

Note: Since silver nitrate can be expensive, this demonstration is best performed using a document camera rather than on an individual basis.

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Procedure:

1. Clean the test tube to be used by rinsing with concentrated nitric acid and washing well with hot water.
2. Prepare Tollen's reagent as follows: Add 50 ml of 0.1 M silver nitrate to the beaker and add NH_4OH to this. A brown precipitate will form. Continue adding ammonium hydroxide until the solution becomes clear. To this, add 25 ml of 0.8 M potassium hydroxide. Again, add ammonium hydroxide until solution becomes clear.
3. To perform demonstration, add 5 ml of dextrose solution to the test tube and to this add 25 ml of Tollen's reagent. The solution will turn yellow and brown then become cloudy and dark before silver begins to form on the inside of the test tube. This should take a couple of minutes.
4. Remove the contents from the test tube and rinse the tube with water. The tube with a "Silver Mirror" can now be passed around for the audience to observe.

Safety:

Wear proper protective equipment including gloves and safety glasses when preparing and performing this demonstration.

Disposal:

Resulting solutions from reactions with aldehyde can be flushed down the drain with plenty of water. Demonstrations using ketones should be discarded in an appropriate waste container. Silver can be recovered by washing the test tube with 1 M nitric acid and evaporating the acid.