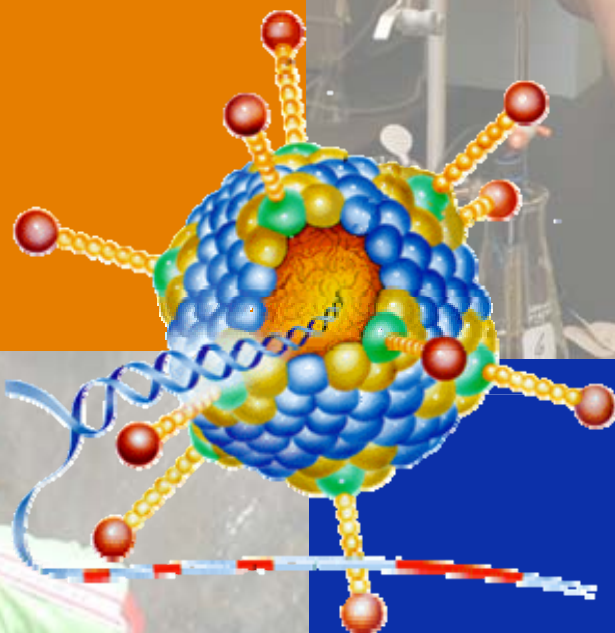


Red Means Lead

Lab Book



*The waterCAMPWS*  
Center for Advanced Materials  
for Purification of Water with Systems



## Overview

The public at large probably sees little relationship between DNA and testing of lead. Yet, the two have been merged through a relatively simple color change test, red indicating lead and blue indicating no lead. Dr. Yi Lu and his graduate student Juewen Liu, at the University of Illinois, Urbana/Champaign, have developed a seemingly simple test reliably indicating the presence or absence of lead. Basing their test upon earlier research using an increase of fluorescence as a positive indicator for lead, Lu and Liu wanted a simpler test: color. In this lab you will use the catalytic DNA compound they created to test for lead in four different samples.

## Materials and Equipment

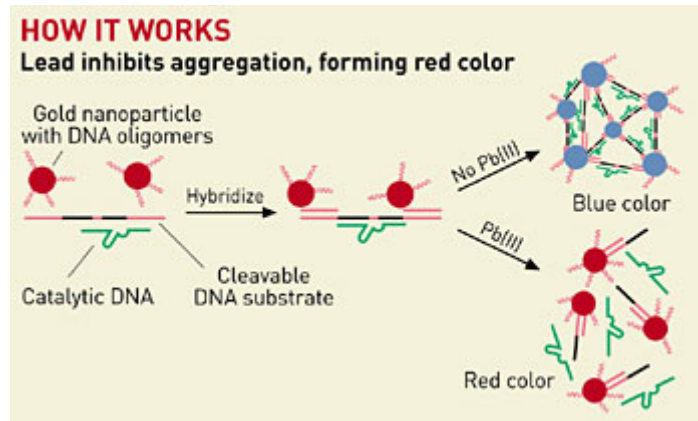
Materials required for this lesson are (for each group of students):

- 4 Capsules of the DNA compound
- 4 prepared beakers of water
- Plastic gloves
- Safety goggles

## Procedure – Part I

Your task is to test the four samples of water in front of you and determine which, if any, contain a percentage of lead. If possible, you should try to indicate which have higher, and thus more harmful, percentages of lead.

1. First, try to determine which, if any, of the samples have a percentage of lead using your senses. **DO NOT TOUCH OR TASTE** the water. Use your sense of smell and sight.
2. Record your observations in the results section.
3. Next, look at each sample under a binocular scope. Shine different types of light through the samples to see if they have different effects.
4. Record your observations in the results section.
5. Take a capsule of the DNA compound, break the capsule and pour the compound into a single beaker and stir.
6. Wait 5-10 minutes to see if the color changes.
7. Observe the samples after 10 minutes. Record your observations in the results section.



## Results

### Observations

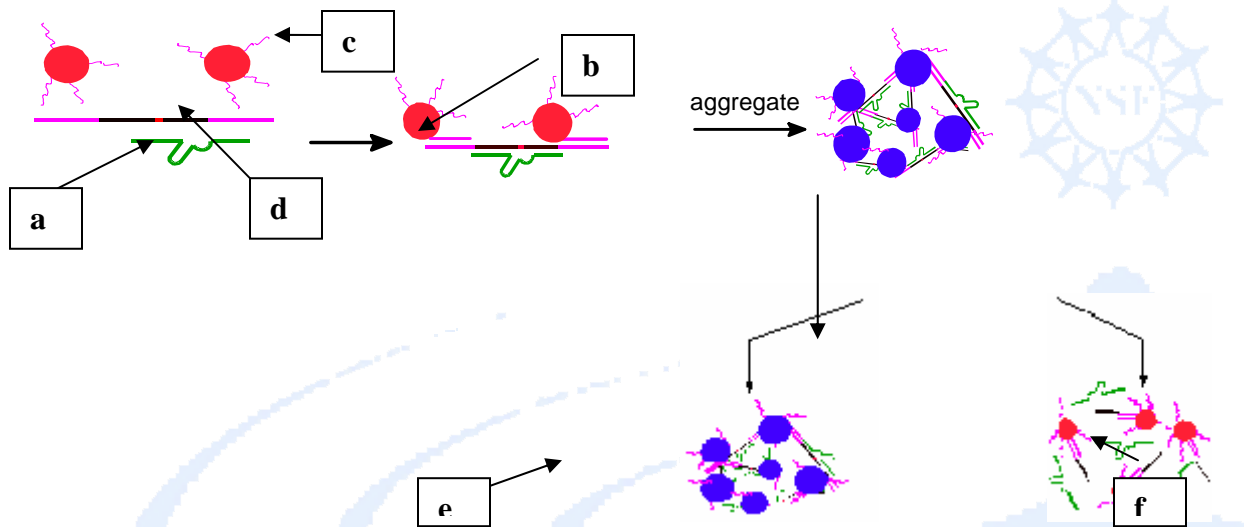
Sight & Smell Alone	Microscope or other Aid	DNA Enzyme Compound
Hypothesis	Hypothesis	Hypothesis

1. Was it possible to detect lead in some way other than the DNA compound? If not, how were you able to make a prediction? What criteria did you use to make your judgement?
2. Which samples contained a percentage of lead? Could you tell which samples had higher percentages of lead? How?

**Biology/Chemistry Activity:**

<u>Word Bank</u>		
Aggregate	Fluorescence	Oligonucleotide(s)
Blue	Gold nanosphere(s)	Red
Catalytic DNA	Micro-	Substrate(s)
	Nano-	

The diagram shown below illustrates the reaction occurring during the DNA lead test. Use it to answer the following questions.



- 1) The structure labeled (a) acts to increase the speed of the reaction, though there is no change in the reaction pathway. \_\_\_\_\_
- 2) \_\_\_\_\_, indicated by (b), become functional as colorimetric indicators of lead when paired with single stranded DNA fragments that act as probes. These fragments are known as \_\_\_\_\_ (c).
- 3) DNAzymes act on the \_\_\_\_\_, labeled (d), which can be cleaved in the presence of lead (II).
- 4) A \_\_\_\_\_ colored product results in the presence of lead (II). Which figure accurately illustrates the product of this reaction? \_\_\_\_\_
- 5)  $10^{-9}$ m, or one billionth of a meter is equal to one \_\_\_\_\_ meter.

**Chemistry Activity:**

In Canada, 10 micrograms per deciliter of blood is (10  $\mu\text{g}/\text{dL}$ ) considered harmful. Given the information below, determine how many grams of lead a 180-lb, adult male can ingest without experiencing any significant health problems.

**Important Conversion Factors**

$$\begin{aligned}1 \text{ lb} &= 0.4536 \text{ kg} \\1 \text{ L H}_2\text{O} &= 1 \text{ kg H}_2\text{O} \\ \text{micro } (\mu) &= 10^{-6} \\ \text{deci (d)} &= 10^{-1}\end{aligned}$$

First, you will need to determine how much blood this individual carries. Blood represents approximately 7% of body mass. (Note that at for individuals living in areas of higher altitudes, blood represents a greater percentage of body mass. Assume 7% for this problem.) How much blood, by mass, does this individual carry?

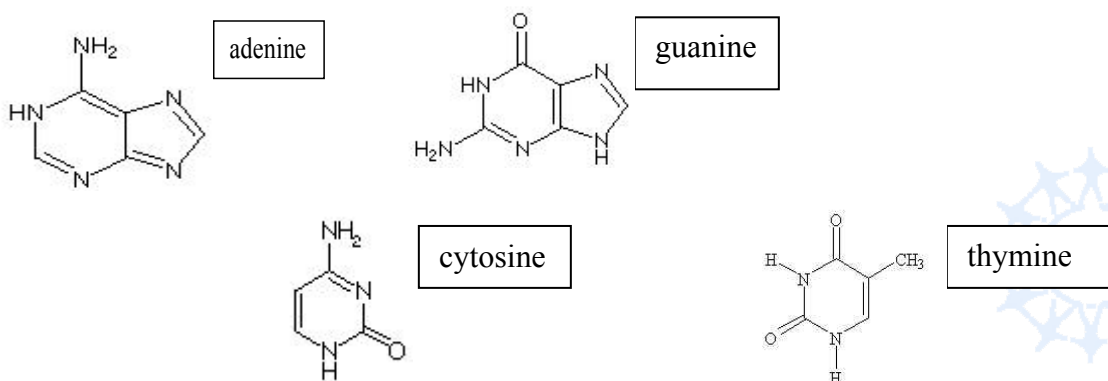
What volume of blood is present in this man's body? (Blood is slightly denser than water, but assume equal densities for this problem.)

How many grams of lead can this person "safely" consume according to Canadian standards?

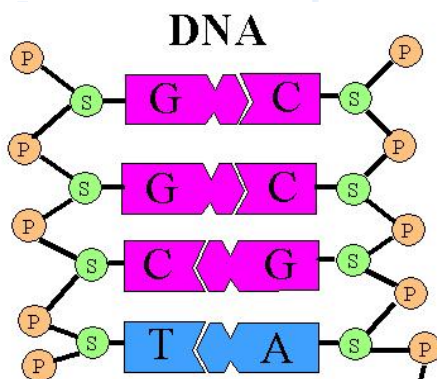
Extension: Visit <http://www.cellsalive.com/howbig.htm> for size/scale activities.

## Biology Activity:

Most DNA in nature exists as a double-stranded polymer. Each strand is comprised of deoxyribonucleosides (deoxyribose molecule linked to one of 4 bases) linked together by phosphate bonds. The four bases present in all DNA (adenosine, guanine, cytosine, and thymine) are shown below.



The bases from each strand are linked in an antiparallel alignment (one strand running 5'-3' and the other 3'-5') and are complementary. Hydrogen bonding between functional groups on each base stabilizes the double-helical structure of DNA. Guanine pairs with cytosine, and adenine pairs with thymine as illustrated below.



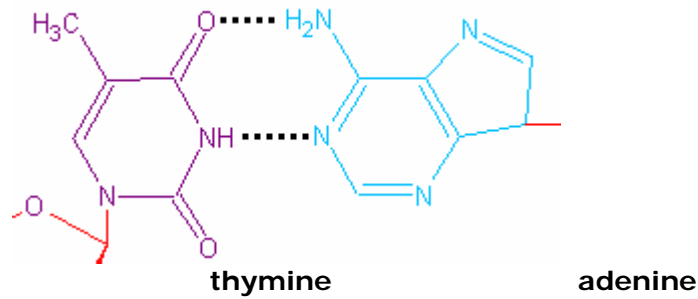
The sequence  
lead sensor test

used for the catalytic DNA enzyme in the  
is:

5'-CAT CTC TTC TCC GAG CCG GTC GAA ATA GTG AGT-3'

1) Write the complimentary sequence for the enzyme (3'-5').

As mentioned earlier, hydrogen bonding is responsible for the structure and pairing of double stranded DNA (dsDNA). Two hydrogen bonds link adenine and thymine when they are paired.



2) Draw the hydrogen bonds for the guanine-cytosine pair.

3) Cleavage of the DNAzyme system occurs at the point indicated below. Why does the strand cleave here? In other words, what is different about the structure at this point that causes the linkage to break?

