Chem/Bio 03 – Fall 09 Problem Set 1 (due Mon 9/14)
Goutte (begin in-class on 9/9)

# Working with numbers and blood cells

Refer to the Table labeled "Your Complete Blood Count". If a range of values is given for a particular entry on the table, pick a convenient value within that range for the sake of making your calculations easier (for ex. you might want to use 5000 as the number of white blood cells/$mm^3$, even though it could just as well be 4900 or 7300 cells/$mm^3$). Please show your work; full credit cannot be given for a number unless your work leading to that number is shown (this also allows you to get partial credit if part of your work was correct, but the final number was off).

1) In your blood, what is the rough ratio of white blood cells (WBC) to red blood cells (RBC)? (ie. for every WBC, how many RBC?)

2) Express the number of WBCs as a percentage of total blood cells, and do the same for RBCs.

3) Consider a tube of 5 cc (= 5 ml!) of blood.
   a. How many WBC are there in this tube?

   b. How many RBC are there in this tube?

4) The average adult body contains about 5 L of blood. What is your total number of WBC and RBC?

5) Let's try to build a useful analogy to help us visualize this number better. Let's expand our RBC's to the size of something we can see: a poppy seed. We can estimate the volume of a poppy seed: it is similar to a mini-cube in which each side measures 1 mm. If so, then the volume of a poppy seed can be estimated to be 1 $mm^3$, which is 1 ul.

   a. What volume (in L) of poppy seeds would represent the number of RBC in your body?

   b. How does this compare to an Olympic size swimming pool (= 2.5 million L)?

6) Thank goodness RBC's are so small. They have the shape of a pinched sphere of which the diameter is 8 micrometers (8 $\mu$m). The volume of a RBC is roughly 100 fL.

   a. Use this volume to calculate the actual volume that *all* of your RBCs would take up if they were packed together instead of floating around in your plasma.

   b. Since you were told that you have about 5 L of blood, what does this tell you about how packed your RBCs are? How does this relate to your "hematocrit"?

7) If you donate blood, the standard donation volume is about a pint of blood, which is roughly ½ Liter.

a. Right after blood donation, what percentage of your blood volume have you lost?

b. What percentage of your RBCs have you lost?

c. How many RBCs is this?

d. Within about one day your body absorbs extra fluid to quickly replenish your plasma; this means your blood volume is restored to 5 L by the next day. In contrast, your body is not as fast to restore the missing blood cells, because they need to be made; this will take a while. Your body is constantly making RBCs to replenish all older RBCs that succumb to wear and tear and fall apart. The rate of RBC production is about 2 million per second (!!). This rate simply keeps up with a similar rate of destruction (2 million RBCs destroyed per second). So in order to restore your normal RBC count after a blood donation, your bone marrow will need to increase its RBC production above the usual 2 million /sec. Consider that in response to blood loss your bone marrow *doubles* the rate of RBC production (it can even increase more than this!), so that you have an *extra* 2 million RBCs generated each second. This seems like a lot; with all these extra RBCs, how quickly would you restore your normal blood count after a blood donation?

e. If your hematocrit was 50% right before blood donation, what is it right after blood donation?

f. Would your hematocrit be the same, or lower, or higher the next day? Explain your answer.

8) Suppose you were given a sample of blood to look at under a microscope and you noticed that the ratio of WBC to RBC is 10:1. Having done problem # 1 on this worksheet, you immediately recognize this blood sample as very abnormal.

a. Suggest two alternative explanations for the 10:1 ratio (almost *anything* is possible!)

b. Explain how a quick hematocrit measurement would help you assess what might be going on.

9) A hematocrit is a very quick and easy measurement. It can immediately signal some abnormal conditions. Explain whether or not you would expect the hematocrit to look abnormal for an individual suffering from each of the following conditions, and if you think the hematocrit would be abnormal, indicate whether you think it would be high or low. Unhealthy hematocrit hematocrit measurements can go as low as 30% or as high as 70%, depending on the condition.

a. Anemia (from not enough red blood cells made, or too many RBCs rupturing, or chronic hemorrhaging)

b. High altitude adjustment (increased RBC production)

c. Dehydration (from profuse diarrhea or heavy sweating)

d. Bacterial Infection

## Units for measuring volume (metric system)

What does "1 cc" of blood mean?

Golden rule: **1cc = 1 cubic centimeter (1 $cm^3$) = 1 milliliter (1 ml)**

Here's a table that lists metric volume units and illustrates the relationship between $cm^3$ (which you might use if you are calculating volume of a cube or a cell) and ml (which you might use if you are measuring liquid volume). Since we may want to convert from one to another, it is useful to understand how these measurements are related to one another.
(note: this is MUCH easier than using inches, tablespoons and pints!)

| | Volume | | | |
|---|---|---|---|---|
| | In cubic meters | In metric volume units | Scientific notation (Liters) | As a fraction of a Liter |
| 4 bath tubs → | 1 $m^3$ | 1 Kl (Kilo-) | $10^3$ L | 1000 L |
| | | 1 L | $10^0$ L | 1 L |
| small dice → | 1 $cm^3$ | 1 ml (milli-) | $10^{-3}$ L | 1/1000 L |
| poppy seed → | 1 $mm^3$ | 1 μl (micro-) | $10^{-6}$ L | $1/10^6$ L |
| | | 1 nl (nano-) | $10^{-9}$ L | $1/10^9$ L |
| | | 1 pl (pico-) | $10^{-12}$ L | $1/10^{12}$ L |
| | 1 $\mu m^3$ | 1 fl (femto-) | $10^{-15}$ L | $1/10^{15}$ L |

Notice that 1 μl is a volume equal to that of a cube which has each side measuring 1mm; if each side of the cube is 10x larger (1 cm), then the volume of that larger cube is going to be 10 x 10 x 10 x larger (ie. 1000x larger).