Step 2. Common Blood Tests, and the “Coulter Counter Readout”

We will be learning about some common blood tests. We will not be preforming most of them in lab. The student should know their names, their abbreviations on a sample blood test “readout” (“Coulter Counter Readout”), and the units involved. The student should be able to analyze a mock “Coulter Counter Readout”, which we are using to represent what one might see in a clinical setting.

A) Hematocrit.

Your hematocrit is the **percent by volume** of your blood that is cellular (as opposed to plasma), technically the percent by volume of RBCs. Males have an average hematocrit of 38-54%, females 36-47%. A males higher hematocrit is due to the average increase in size and muscle mass, and therefore a greater need for oxygen transport.

Altitude also greatly affects hematocrit. For high altitude residents: about 45% - 61% in males; 41% - 56% in females (These levels gradually average higher as the altitude where people live increases. This is a result of the increased demand for the oxygen-carrying capacity of red blood cells at higher altitudes where there is decreased oxygen concentration in the atmosphere.)

Readings outside of these normal ranges can indicate a blood abnormality.

Blood analyzers, such as the Coulter Counter, estimate hematocrits in a fraction of a second. The abbreviation is Hct.

An alternative method is to centrifuge blood that has been collected in a capillary tube, and then estimate hematocrit using a "reader" device of some sort. Hematocrits taken by use of a centrifuge are referred to as "spun" hematocrits.
B) Blood Clotting – A review from lecture material

The ability of the blood to form a clot protects the individual from excessive bleeding from minor wounds. These test ARE NOT given on the Coulter Counter Readout!

In lecture, we saw that the process of blood clotting first involves “intrinsic and extrinsic pathway”, which lead to a “common pathway”. Please see the lecture notes for details. Here is a summary that is important to understanding clotting tests done in a lab. You should check to see if you can follow it on the diagram below:

**The intrinsic and extrinsic pathways: Forming a molecule called “Prothrombin Activator”:**

The reactions that lead to prothrombin activation involve calcium ions, a substance called thromboplastin, blood platelets and chemicals they contain which we will call platelet factors, and a group of chemical compounds which we will call the accessory factors. A possible scheme for the interaction of the above is described in your text and will also be discussed in lecture.

**The Common Pathway: Forming Fibrin:**

Clotting involves two plasma proteins, prothrombin and fibrinogen, both of which are synthesized in the liver.

To form a clot prothrombin must first activate to thrombin.

Thrombin in turn causes fibrinogen to convert to active fibrin.

Fibrin is a protein that organizes into long, sticky threads that form the basic meshwork of the clot.

Bleeding stops when the fibrin mesh has become fine enough to trap RBCs, thus forming a plug of fibrin and RBCs which blocks the wound.
Vitamin K is also important for clotting in that it is needed for the synthesis of prothrombin by the liver.

Intravascular clotting within healthy vessels is normally prevented by an anticoagulant called **heparin** which is present in the plasma. Heparin is thought to be produced by **mast cells** found in the tissues of various organs.

*Neither of these two tests we will study are tests we have current capability to do in lab at MATC. Know their names and significance for the lab practical.* Historically, there are a number of different test procedures that have been used to estimate a person's ability to clot. Two of the more sophisticated are:

1. **PT Test = Prothrombin Time Test**

   This test determines the amount of prothrombin in the blood and is a test of the extrinsic clotting pathway and common pathway. It may be used to follow the effects of coumarin, or other Vitamin K inhibitors, since Factor VIII which is part of the extrinsic pathway, but not part of the intrinsic pathway, is most sensitive to Vitamin K.

2. **PTT Test = Partial Thromboplastin Time Test**

   This test is a test of the intrinsic pathway and common pathway.

   If both PT and PTT test times are prolonged, then the problem is with the common pathway.

C) **Other Blood Tests.**

On the Coulter Counter Readout, you may also see the normal ranges and tested values for:

- **Total Red Blood Cell Count** (the number of Erythrocytes per cubic mm of blood). See “Step 3 – Formed Element ID” for a discussion, abbreviations and values.

- **Total White Blood Cell Count** (the number of ALL white blood cells per cubic mm of blood). See “Step 3 – Formed Element ID” for a discussion, abbreviations and values.

- **Differential White Blood Cell Count** (the percentages of the individual types of White blood cells). See “Step 3 – Formed Element ID” for a discussion, abbreviations and values.

- **Hemoglobin (Hgb)** - The hemoglobin test is often used to check for anemia or polycythemia, usually along with a hematocrit or as part of a complete blood count (CBC).

- **Mean Corpuscular Volume (MCV)** - is a measure of the average volume of a red blood corpuscle. It is HCT/[RBC]. The normal range for MCV is 80–100 fL. This is a test for anemia or polycythemia.

  1 femtoliter = 10^{-15} liter. I will never make the student convert! You do not see this unit very often.

- **Mean Cell Hemoglobin (MCH)**, is the average mass of hemoglobin per red blood cell in a sample of blood. This is a test for anemia and polycythemia.

- **Mean Corpuscular Hemoglobin concentration (MCHC)** is the average concentration of hemoglobin in red blood cells. This is a test for anemia and polycythemia.

- **Coagulation Time** – how long it take to coagulate. **Do not worry about normal ranges.** This can be used to monitor anticoagulation effects, such as high-dose heparin before, during, and shortly after procedures that require intense anticoagulant administration, such as cardiac bypass, cardiac angioplasty, thrombolysis, extra-corporeal membrane oxygenation (ECMO) and continuous dialysis. **This test is not on the Coulter Counter Readout.**
Red blood cell distribution width (RDW) is a measure of the range of variation of red blood cell (RBC) volume that is reported as part of a standard complete blood count. Usually red blood cells are a standard size of about 6-8 µm in diameter. Certain disorders, however, cause a significant variation in cell size.

Example “Coulter Counter Readout”

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Test Value</th>
<th>Unit</th>
<th>Range #1</th>
<th>Range #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>3.4 L</td>
<td>x10^9/uL</td>
<td>3.6 - 9.6</td>
<td>3.9 - 5.7</td>
</tr>
<tr>
<td>LY%</td>
<td>45.4</td>
<td>%</td>
<td>20.5 - 51.1</td>
<td>12.1 - 17.2</td>
</tr>
<tr>
<td>MO%</td>
<td>4.4</td>
<td>%</td>
<td>1.7 - 9.3</td>
<td>36.1 - 50.3</td>
</tr>
<tr>
<td>GR%</td>
<td>50.2</td>
<td>%</td>
<td>42.2 - 75.2</td>
<td>82.2 - 97.4</td>
</tr>
<tr>
<td>LY#</td>
<td>1.5</td>
<td>x10^9/uL</td>
<td></td>
<td>27.6 - 33.3</td>
</tr>
<tr>
<td>MO#</td>
<td>0.1</td>
<td>x10^9/uL</td>
<td></td>
<td>33.0 - 34.8</td>
</tr>
<tr>
<td>GR#</td>
<td>1.7</td>
<td>x10^9/uL</td>
<td></td>
<td>11.6 - 13.7</td>
</tr>
</tbody>
</table>

Key:
- WBC = white blood cell
- LY = lymphocyte
- MO = monocyte
- GR = granulocyte
- Hgb = hemoglobin
- RBC = red blood cell
- PLT = platelet
- MCV = mean corpuscular volume
- MCH = mean corpuscular hemoglobin
- MCHC = mean corpuscular hemoglobin concentration
- Hct = hematocrit
- H = higher than expected
- L = lower than expected
- * = questionable result

Range #1: 3.6 - 9.6, 20.5 - 51.1, 1.7 - 9.3, 42.2 - 75.2, 1.5 x10^9/uL, 0.1 x10^9/uL, 1.7 x10^9/uL

Range #2: 3.9 - 5.7, 12.1 - 17.2, 36.1 - 50.3, 82.2 - 97.4, 27.6 - 33.3, 33.0 - 34.8, 11.6 - 13.7