Blood Analysis

Advance Preparation, Comments, and Pitfalls

Consider doing a short introductory presentation with the following elements:

- Describe what happens to whole blood when it is centrifuged.
- Explain the importance of erythropoietin in regulating erythropoiesis.
- Describe the shape of red blood cells and how they settle in a test tube.
- Show students the structure of hemoglobin and explain its function.
- Describe the ABO and Rh blood groups.
- Explain why total cholesterol determination is an important diagnostic tool.

Answers to Questions/Experimental Data

Pre-lab Quiz in the Lab Manual

1. c. platelets
2. erythrocytes
3. c. monocyte
4. a. Basophils
5. hematocrit
6. antigens
7. True

Activity 1: Hematocrit Determination (pp. PEx-162–PEx-164)

Predict Question 1: The hematocrits of the Denver residents will be higher than those of the Boston residents.

Chart 1: Hematocrit Determination

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total height of column of blood (mm)</th>
<th>Height of red blood cell layer (mm)</th>
<th>Height of buffy coat (mm)</th>
<th>Hematocrit</th>
<th>% WBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1 (healthy male living in Boston)</td>
<td>100 mm</td>
<td>48 mm</td>
<td>1 mm</td>
<td>48</td>
<td>1</td>
</tr>
<tr>
<td>Sample 2 (healthy female living in Boston)</td>
<td>100 mm</td>
<td>44 mm</td>
<td>1 mm</td>
<td>44</td>
<td>1</td>
</tr>
<tr>
<td>Sample 3 (healthy male living in Denver)</td>
<td>100 mm</td>
<td>55 mm</td>
<td>1 mm</td>
<td>55</td>
<td>1</td>
</tr>
<tr>
<td>Sample 4 (healthy female living in Denver)</td>
<td>100 mm</td>
<td>53 mm</td>
<td>1 mm</td>
<td>53</td>
<td>1</td>
</tr>
<tr>
<td>Sample 5 (male with aplastic anemia)</td>
<td>100 mm</td>
<td>19 mm</td>
<td>0.5 mm</td>
<td>19</td>
<td>0.5</td>
</tr>
<tr>
<td>Sample 6 (female with iron-deficiency anemia)</td>
<td>100 mm</td>
<td>32 mm</td>
<td>1 mm</td>
<td>32</td>
<td>1</td>
</tr>
</tbody>
</table>
Activity Questions:

1. The hematocrit is calculated by dividing the height of the RBC layer by the total height of the blood and multiplying by 100%. The resulting percentage is the portion of the blood that contains RBCs.

2. The buffy coat contains a layer of white blood cells which are lighter than the red blood cells and therefore end up in between the red blood cells and the plasma after centrifugation.

3. The individual described has a hematocrit that is slightly higher than normal. Given the effects of testosterone, this individual probably has higher than normal levels of testosterone for her gender.

Activity 2: Erythrocyte Sedimentation Rate (pp. PEx-164–PEx-165)

Predict Question 1: The sedimentation rate for sample 6 will be the same as sample 1.

Chart 2: Erythrocyte Sedimentation Rate

<table>
<thead>
<tr>
<th>Blood sample</th>
<th>Distance RBCs have settled (mm)</th>
<th>Elapsed time</th>
<th>Sedimentation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1 (healthy individual)</td>
<td>5 min</td>
<td>60 mm</td>
<td>5 mm/hr</td>
</tr>
<tr>
<td>Sample 2 (menstruating female)</td>
<td>15 min</td>
<td>60 mm</td>
<td>15 mm/hr</td>
</tr>
<tr>
<td>Sample 3 (individual with sickle cell anemia)</td>
<td>0 min</td>
<td>60 mm</td>
<td>0 mm/hr</td>
</tr>
<tr>
<td>Sample 4 (individual with iron-deficiency anemia)</td>
<td>30 min</td>
<td>60 mm</td>
<td>30 mm/hr</td>
</tr>
<tr>
<td>Sample 5 (individual suffering a myocardial infarction)</td>
<td>40 min</td>
<td>60 mm</td>
<td>40 mm/hr</td>
</tr>
<tr>
<td>Sample 6 (individual with angina pectoris)</td>
<td>5 min</td>
<td>60 mm</td>
<td>5 mm/hr</td>
</tr>
</tbody>
</table>

Activity Questions:

1. ESR can be used to follow the progression of certain diseases. When the disease worsens, the ESR increases.

2. An accelerated ESR can be caused by certain disease conditions where the RBCs clump together, stack up, and form a dark red column (rouleaux formation) which is heavier and settles faster.

Activity 3: Hemoglobin Determination (pp. PEx-165–PEx-167)

Predict Question 1: The hemoglobin levels for the female Olympic athlete will be greater than those for the healthy female.

Chart 3: Hemoglobin Determination

<table>
<thead>
<tr>
<th>Blood sample</th>
<th>Hb in grams per 100 ml of blood</th>
<th>Hematocrit (PCV)</th>
<th>Ratio of PCV to Hb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1 (healthy male)</td>
<td>16</td>
<td>48</td>
<td>3:1</td>
</tr>
<tr>
<td>Sample 2 (healthy female)</td>
<td>14</td>
<td>44</td>
<td>3.14:1</td>
</tr>
<tr>
<td>Sample 3 (female with irondeficiency anemia)</td>
<td>8</td>
<td>40</td>
<td>5:1</td>
</tr>
<tr>
<td>Sample 4 (male with polycythemia)</td>
<td>20</td>
<td>60</td>
<td>3:1</td>
</tr>
<tr>
<td>Sample 5 (female Olympic athlete)</td>
<td>22</td>
<td>60</td>
<td>2.73:1</td>
</tr>
</tbody>
</table>

Activity Questions:

1. Individuals living at higher elevation need a greater oxygen carrying capacity because there is less oxygen at higher elevations. Increased hemoglobin levels would provide a greater oxygen carrying capacity.

2. The more oxygen that the blood is carrying the brighter the red color. Blood that is poorly oxygenated has a dull brick-red appearance.

Activity 4: Blood Typing (pp. PEx-167–PEx-169)

Predict Question 1: If the patient’s blood type is AB−, the appearance would be A, clumpy; B, clumpy; Rh, unclumped.
Chart 4: Blood Typing Results

<table>
<thead>
<tr>
<th>Blood sample</th>
<th>Agglutination with anti-A serum</th>
<th>Agglutination with anti-B serum</th>
<th>Agglutination with anti-Rh serum</th>
<th>Blood type*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>positive</td>
<td>negative</td>
<td>positive</td>
<td>A+</td>
</tr>
<tr>
<td>2</td>
<td>negative</td>
<td>positive</td>
<td>positive</td>
<td>B+</td>
</tr>
<tr>
<td>3</td>
<td>positive</td>
<td>positive</td>
<td>negative</td>
<td>AB−</td>
</tr>
<tr>
<td>4</td>
<td>negative</td>
<td>negative</td>
<td>negative</td>
<td>O−</td>
</tr>
<tr>
<td>5</td>
<td>positive</td>
<td>positive</td>
<td>positive</td>
<td>AB+</td>
</tr>
<tr>
<td>6</td>
<td>negative</td>
<td>positive</td>
<td>negative</td>
<td>B−</td>
</tr>
</tbody>
</table>

* The entries in this column are designated by the student.

Activity Questions:
1. For blood type AB−, antigens present would be A and B. Antibodies present would be none. (note Rh antibodies only occur with prior sensitization.)
   For blood type O+, Rh antigens present. Antibodies present would be anti-A and anti-B.
   For blood type B−, B antigens present. Antibodies present would be anti-A.
   For blood type A+, A and Rh antigens present. Antibodies present would be anti-B.
2. The recipients blood type changes to that of the bone marrow donor.

Activity 5: Blood Cholesterol (pp. PEx-169–PEx-171)

Predict Question 1: Based upon his dietary preference, you anticipate his total cholesterol level to be abnormally high.

Chart 5: Total Cholesterol Determination

<table>
<thead>
<tr>
<th>Blood sample</th>
<th>Approximate total cholesterol (mg/dL)</th>
<th>Cholesterol level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>150</td>
<td>desirable*</td>
</tr>
<tr>
<td>2</td>
<td>300</td>
<td>elevated*</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>desirable*</td>
</tr>
<tr>
<td>4</td>
<td>225</td>
<td>borderline elevated*</td>
</tr>
</tbody>
</table>

* The entries in this column are designated by the student.

Activity Questions:
1. The arteries are subject to greater pressure which can lead to damage to the endothelium. This damage results in plaques.
2. Phytosterols stop or slow absorption of dietary cholesterol and cholesterol made by the liver which should lower the amount of LDLs in the blood.
ACTIVITY 1  Hematocrit Determination

1. List the hematocrits for the healthy male (sample 1) and female (sample 2) living in Boston (at sea level) and indicate whether they are normal or whether they indicate anemia or polycythemia. The healthy male hematocrit was 48% and the healthy female hematocrit was 44%. They were both normal for their respective gender.

2. Describe the difference between the hematocrits for the male and female living in Boston. Why does this difference between the sexes exist? The hematocrit for the female living in Boston was lower than the male. The difference is because males have more testosterone which promotes RBC production.

3. List the hematocrits for the healthy male and female living in Denver (approximately one mile above sea level) and indicate whether they are normal or whether they indicate anemia or polycythemia. The hematocrits for the male and female living in Denver are 55% and 53% respectively. Both values indicate polycythemia, an adaption to living at high altitude.

4. How did the hematocrit levels of the Denver residents differ from those of the Boston residents? Why? How well did the results compare with your prediction? The hematocrits for the Denver residents were higher as predicted. This is because there is less oxygen in the air at higher elevation.

5. Describe how the kidneys respond to a chronic decrease in oxygen and what effect this has on hematocrit levels. The kidneys respond to a decrease in oxygen by releasing more EPO (erythropoietin) which stimulates the production of red blood cells.

6. List the hematocrit for the male with aplastic anemia (sample 5) and indicate whether it is normal or abnormal. Explain your response. The hematocrit for the male with aplastic anemia is 19%, below the acceptable range. Aplastic anemia can result from the destruction of RBCs or the inhibition of red marrow.

7. List the hematocrit for the female with iron-deficiency anemia (sample 6) and indicate whether it is normal or abnormal. Explain your response. The iron-deficient female has a hematocrit of 32%, abnormally low. Iron-deficiency is often accompanied by a low hematocrit.
**Activity 2**

**Erythrocyte Sedimentation Rate**

1. Describe the effect that sickle cell anemia has on the sedimentation rate (sample 3). Why do you think that it has this effect?

   *The sedimentation rate was dramatically lower in the sickle cell anemia sample. This is because of the abnormal shape of the RBCs. They do not form stacks of cells.*

2. How did the sedimentation rate for the menstruating female (sample 2) compare with the sedimentation rate for the healthy individual (sample 1)? Why do you think this occurs?

   *The sedimentation rate for the menstruating female was faster than the healthy individual probably due to the fact that she is anemic.*

3. How did the sedimentation rate for the individual with angina pectoris (sample 6) compare with the sedimentation rate for the healthy individual (sample 1)? Why? How well did the results compare with your prediction?

   *The sedimentation rate was the same. The sedimentation rate was not elevated because the individual hasn't had a myocardial infarction.*

4. What effect does iron-deficiency anemia (sample 4) have on the sedimentation rate?

   *Iron-deficiency results in an increase in the sedimentation rate.*

5. Compare the sedimentation rate for the individual suffering a myocardial infarction (sample 5) with the sedimentation rate for the individual with angina pectoris (sample 6). Explain how you might use this data to monitor heart conditions.

   *The sedimentation rate for the individual suffering an MI is increased but is normal for the individual with angina. Elevated ESR can be indicative of an MI event.*

**Activity 3**

**Hemoglobin Determination**

1. Is the male with polycythemia (sample 4) deficient in hemoglobin? Why?

   *No, the male with polycythemia is not deficient in hemoglobin. His ratio of PCV to hemoglobin is 3:1, normal.*

2. How did the hemoglobin levels for the female Olympic athlete (sample 5) compare with the hemoglobin levels for the healthy female (sample 2)? Is either person deficient in hemoglobin? How well did the results compare with your prediction?

   *The hemoglobin levels for the female Olympic athlete were higher than the healthy female. Neither person is deficient in hemoglobin.*

3. List conditions in which hemoglobin levels would be expected to decrease. Provide reasons for the change when possible.

   *Hemoglobin levels decrease in patients with anemia, hyperthyroidism, cirrhosis of the liver, renal disease, systemic lupus erythematosus, and severe hemorrhage.*
4. List conditions in which hemoglobin levels would be expected to increase. Provide reasons for the change when possible.

*Hemoglobin levels increase in patients with polycythemia, congestive heart failure, chronic obstructive pulmonary disease (COPD) and when living at high altitudes.*

5. Describe the ratio of hematocrit to hemoglobin for the healthy male (sample 1) and female (sample 2). (A normal ratio of hematocrit to grams of hemoglobin is approximately 3:1.) Discuss any differences between the two individuals. *Both ratios are approximately 3:1 which is normal. The ratio for the female was 3.14:1, slightly higher than the male ratio of 3:1.*

6. Describe the ratio of hematocrit to hemoglobin for the female with iron-deficiency anemia (sample 3) and the female Olympic athlete (sample 5). (A normal ratio of hematocrit to grams of hemoglobin is approximately 3:1.) Discuss any differences between the two individuals. *The ratio for the iron-deficient female was 5:1 which is not normal. The ratio for the female Olympic athlete was 3:1.*

**Activity 4** Blood Typing

1. How did the appearance of the A, B, and Rh samples for the patient with AB– blood type compare with your prediction? *With blood type is AB–, the appearance was A, clumpy; B, clumpy; Rh, unclumped.*

2. Which blood sample contained the rarest blood type? *Sample 3 contains the rarest blood type, AB negative. If you have this blood type the blood banks have you on speed dial.*

3. Which blood sample contained the universal donor? *Sample four contained the universal donor, O–.*

4. Which blood sample contained the universal recipient? *Sample 5 contains the universal recipient, AB positive. It is the universal recipient because all of the antigens are present on the surface of the RBCs.*

5. Which blood sample did not agglutinate with any of the antibodies tested? Why? *Sample 4 did not agglutinate with any of the antibodies tested. This is because none of the antigens were present.*

6. What antibodies would be found in the plasma of blood sample 1? *Antibodies against the B antigens because the blood type for sample #1 is A+.*

7. When transfusing an individual with blood that is compatible but not the same type, it is important to separate packed cells from the plasma and administer only the packed cells. Why do you think this is done? (Hint: Think about what is in plasma versus what is on RBCs.) *The plasma contains antibodies that will react with the individual’s RBCs if they do not have the exact same blood type.*
8. List the blood samples in this activity that represent people who could donate blood to a person with type B+ blood.

The following samples could donate: sample #2 because it is B+, sample #4 because it is O−, the universal donor and sample #6 because it is B−.

**ACTIVITY 5** Blood Cholesterol

1. Which patient(s) had desirable cholesterol level(s)? **Patients 1 and 3 had desirable cholesterol levels because they were both approximately 150 mg/dL.**

2. Which patient(s) had elevated cholesterol level(s)? **Patient 2 had elevated cholesterol at 300 mg/dL.**

3. Describe the risks for the patient(s) you identified in question 2. **Patient 2 is at risk for heart disease since elevated cholesterol can lead to blocking of the path of blood to the heart.**

4. Was the cholesterol level for patient 4 low, desirable, or high? How well did the results compare with your prediction? What advice about diet and exercise would you give to this patient? Why? **Patient 4 was in the range of borderline elevated. It is not in the desirable range but not quite elevated. So, his diet should be modified to limit fat intake.**

5. Describe some reasons why a patient might have abnormally low blood cholesterol. **One reason for low blood cholesterol is an overactive thyroid gland. Other reasons are thought to be linked to mood and the neurotransmitter serotonin.**