Circulation Continued

1. List the three ways fetal blood circulation differs from adult circulation? Compare the location of oxygenated and deoxygenated blood in fetal and adult circulation
   a. Foramen Ovale: an opening between the atria that helps to bypass the lungs
      (an easy way to remember this is the O in ovale stands for opening!)
   b. Ductus Arteriosus: connects the pulmonary artery to the aorta
      (think Arteriosus → artery)
   c. Ductus Venosus: shunts blood away from the capillaries in the liver to the vena cava
      (venosus → hepatic portal vein)
   • all of these methods help to keep the fetal work to a minimum… think about it! Why would the baby need to send its blood to the lungs with it gets oxygenated blood from the mother? No need to store nutrients in the liver, baby gets everything it needs from mom

In the fetus the umbilical artery carries blood away from the heart and towards the placenta. The umbilical vein carries blood away from the placenta and towards the heart. So, the artery carries deoxygenated blood (because they will pick up o2 in the placenta) and the vein carries oxygenated blood (because they are leaving the placenta with fully oxygenated blood)

2. Compare fetal and adult hemoglobin
    Fetal Hb has 2 alpha and 2 gamma chains while adult Hb has 2 alpha and 2 beta chains. What’s the difference? Fetal Hb has a higher affinity for oxygen than adult so the fetus can get the oxygen from the mothers blood (because the fetus has a higher affinity for the oxygen it “pulls” the oxygen from the mothers blood)

Immunology
Part I: Blood

3. Complete the chart with the components of blood

<table>
<thead>
<tr>
<th>Blood Plasma (55%)</th>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Solvent</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>Osmotic balance, pH buffering, and regulation of membrane permeability (i.e: Na/K pump)</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicarbonate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasma Proteins:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albumin</td>
<td>Osmotic balance, pH buffering</td>
<td></td>
</tr>
<tr>
<td>Fibrinogen</td>
<td>Clotting</td>
<td></td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>Defense</td>
<td></td>
</tr>
</tbody>
</table>
4. Describe the cellular components of blood and list their function
   a. Erythrocytes: most numerous, concave shape to increase SA to carry oxygen, lack nuclei and
      organelles to make more room for oxygen, made in the bone marrow of flat bones
      - low oxygen stimulates the kidneys to make erythropoietin which travels to the bone
      marrow and stimulates it to send out more blood cells
   b. Leukocytes: white blood cells, function in fighting infections,
   c. Platelets: cell fragments that function in blood clotting

5. How does the process of blood clotting occur?
   1. When there is an injury collagen fibers are exposed
   2. Platelets see these and send out a sticky substance that attracts other platelets
      - these are called clotting factors
   3. Clotting factors stimulate release of zymogens from liver: Prothrombin and Fibrinogen
   4. Thrombin can activate itself or activate fibrin which creates fibers (produces a clot)
   5. Plasmin breaks down the clot

6. Describe how stem cells differentiate

   stem cells can become lymphoid stem cells or myeloid stem cells
   - lymphoid stem cells become b and t cells (lymphocytes)
   - myeloid stem cells become red and white blood cells

7. Complete the chart with the function of each leukocyte

<table>
<thead>
<tr>
<th>WBC</th>
<th>Function/ Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutrophils</td>
<td>Phagocytic, monocyte</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>Function in allergic reactions and parasitic invasions</td>
</tr>
<tr>
<td>Basophils</td>
<td>Release histamine during inflammation</td>
</tr>
</tbody>
</table>

8. Describe carbon dioxide transport in the blood

   CO2 is made as a by-product during cellular respiration. It moves by diffusion from tissues, then into
   interstitial fluids, next into the capillary, and lastly into the RBC. CO₂ combines with water to form carbonic
   acid (H₂CO₃) and then breaks down into bicarbonate and hydrogen ion. Bicarbonate travels through the
   blood plasma → THIS IS THE MAJOR WAY CO₂ IS TRANSPORTED IN THE BODY. The hydrogen ion (H⁺) is a
   negative allosteric modulator for hemoglobin. The increase in H⁺ concentration, which correlates to a drop
   in pH (more acidic), causes the hemoglobin molecule to change shape and release oxygen

   In the lungs, bicarbonate enters the RBC again and forms with H⁺ to make carbonic acid. Carbonic acid
   breaks down into CO₂ and water. CO₂ diffuses into the lungs

9. Draw a graph with the general shapes of the two conditions:
   a. One curve showing hemoglobin dissociation at pH 7.4
   b. Second curve showing hemoglobin dissociation at acidic pH
10. What is happening in the graph you drew?
Bohr shift! An acidic pH is not good for the body. It means you have low oxygen concentration and high carbon dioxide concentration. When the body is low in oxygen, hemoglobin wants to get rid of its oxygen molecules to restore the pH. Hemoglobin’s affinity for oxygen will drop at a low pH so it can unload its oxygen more readily. This shifts the line in the graph to the right. When hemoglobin has a higher affinity for oxygen than normal it will cause the graph to shift to the left. For example, fetal hemoglobin, which has a higher affinity of O2 than adult hemoglobin, will be to the left on the graph.

Part II: Lymphatic system
11. How does the lymphatic system get rid of excess fluid?
Fluid pushed out of capillaries enters the lymphatic system.
Lymphatic and thoracic duct $\rightarrow$ right lymphatic duct $\rightarrow$ fluid dumped into large subclavian veins in the chest

Part III: Types of Immunity
12. Describe the components of the two types of immunity

<table>
<thead>
<tr>
<th>Innate Immunity</th>
<th>Acquired Immunity</th>
</tr>
</thead>
</table>
| Barrier defenses:
  Skin with bacteria
  Mucous membranes trap and slow invaders down
  Secretions contain enzymes and pH conditions that can kill some invaders | Humoral response:
  Antibodies released to fight |
|                                                      | Cell-mediated response:                |
Internal defenses:
- Phagocytic cells contain lysozymes that will break invaders down
- Antimicrobial proteins
- Inflammatory response
- Natural Killer Cells

Cytotoxic t-cells fight the infection

- Phagocytic cells:
  - Neutrophils are the first on the scene
  - Eosinophils attack big things
  - Dendritic cells play a role in acquired immunity
  - Basophils release histamine
  - Macrophages bridge the gap between innate and acquired immunity

- Toll Like Receptors
  - Present on the surface of our white blood cells. These receptors look for things like flagellin and other bacteria specific things like lipopolysaccharide and RNA as genetic material

- Antimicrobial proteins
  - Ex: Interferons released in response to viruses

13. Describe the process of the inflammatory process
   1. Something enters your tissue that brings in bacteria (for example)
   2. Basophils enter through the blood stream and release histamine (mast cells also release histamine)
   3. Histamine causes vasodilation (the direct effect)
      This increase in blood flow allows more phagocytic cells to enter the area
   4. Increased blood flow leads to indirect effects like: redness, leakiness of valves, swelling, heat
   5. Chemical signals cause stimulate neutrophils to leave the blood vessel and enter tissue
   6. Neutrophils kill or digest the pathogen

14. What is the complement system?
It bridges the gap between innate and acquired immunity. This system contains zymogens that when activated poke holes in cells and cause them to lyse

15. How does our body generate a fever? (not test material but in case you are interested)
Macrophones send out the peptide Interleukin, which is a type of cytokine. The hypothalamus has receptors for this interleukin-1 cytokine. When the cytokine is produced it binds to receptors on the hypothalamus and causes the body to reset its temperature. A higher temperature is acquired by 1) increasing metabolism and 2) shivering. When you shiver you generate body heat but you are also cold so you will want to cover up which will increase body temp