Please print your name: ______________________________________

Instructions:

Please write only on these pages, in the spaces allotted and not on the back. Write your number on each page (not your name), so that we can split them up and grade them anonymously. There are a total of 6 pages including this cover page. You may not use any books or notes, and no electronic aids, including calculators.

Answer only in the space provided; short, concise answers are preferred and will be rewarded. Please be as neat as possible.
1. In class two equations that relate membrane potential and ion concentrations were discussed: the Goldman-Hodgkin-Katz (GHK) equation and the Nernst equation. Explain (1) what does the numerical value computed from each equation represent, and (2) why does the GHK equation provide a better description of membrane potential as a function of potassium (K) concentration? (4 points)

2. Please fill in the following table with the term “higher”, “lower” or “equal” (4 points).

<table>
<thead>
<tr>
<th></th>
<th>Extracellular concentration</th>
<th>Intracellular concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K⁺</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Ca²⁺</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. In mammalian cells what generally is the common cellular effect of all action potentials? (2 points)

4. What property of Na channels causes the refractoriness of an excitable cell? (2 points)
5. Label what a, b, c, d, and e represent on the graph below: (5 points)

Currents During an Action Potential

Time Course of Currents

6. True or False (correct if false) A flux of sodium ions into the cell depolarizes the cell membrane, and a flux of potassium ions out of the cell hyperpolarizes the cell membrane. (2 points)

7. True or False (correct if false) At steady-state equilibrium, there is no net flux of individual ions and no net charge movement. (2 points)

Mercer Section (21 points total)

1. Explain the differences between facilitated diffusion, primary active transport, and secondary active transport in terms of energy requirement. (3 points)
2. List the two types of carrier-mediated transport that rely on coupled-transport and comment on the directionality of the solutes being transported. (4 points)

3. Name 2 diseases caused by defects in membrane transport? (2 points)

4. Name two plasma membrane proteins found in tight junctions. (2 points)

5. Patients with mutations in Claudin-16 usually suffer from seizures and die early in life. What function is lost by mutations in Claudin-16? (1 point)
6. Epidermolysis bullosa (EB) is a blistering disorder caused by mutations in which type of junctional complex? (1 point)

7. List one apical sorting signal and one basolateral sorting signal. (2 points)

8. Gap junctions enable electrical and small metabolite communication between cells. What protein complex forms the gap junction? List one condition at which these channels will close to protect the cell. (2 points)

9. True or False (correct if false) In response to ADH (antidiuretic hormone) stimulation, an aquaporin channel is delivered to the basolateral membrane increasing water permeability. (2 points)

10. True or False (correct if false) The Na,K-ATPase pump is generally located exclusively on the apical membrane of mammalian cells. (2 points)
Ken Blumer Section (24 points)

1. List and describe the four modes of cell communication. (4 points)

2. Draw and label a Scatchard plot depicting **Negative cooperativity**. Be sure to label both axes and provide a short description of what negative cooperativity is. (3 points)

3. Match each Ras homolog with the cytoskeletal change it induces. (3 points)
   - Filopodia
   - Stress fibers
   - Lamellipodia
   - A. Rho
   - B. Rac
   - C. Cdc42
4. What are the four classes of cell-surface receptors? (4 points)

5. Draw the CaM-kinase II Regulatory Pathway. Be sure to label where the pathway is calcium dependent and independent. (4 points)

6. MAPK “cassettes” mediate many different biological responses. List 3 reasons why three different organisms that have similar cassettes, have three kinases? (3 points)
7. Match the signaling speed with its function. (3 points)

____ Very fast (milliseconds)  A. G protein-coupled receptors
____ Fast (seconds)           B. Ion channels
____ Slow (minutes to hours)  C. Growth factor receptors

Ron Bose Signal Transduction Section (13 Points)

1. What kind of defects/abnormalities do nuclear hormone receptor knock-out mice have? (3 points)

2. Diagram the PI3-kinase-Akt pathway (acronyms are fine). (4 points)

3. mTOR has two distinctive protein complexes that regulate different cellular process. Provide a short description of each complex. (4 points)
4. Describe two methods by which protein kinases are regulated (2 points)

**Stephen Oh Section (10 points)**

1. Briefly describes how elemental mass cytometry works. Why would you use this technique over flow cytometry? (4 points)

2. Draw out the mechanism of the drug imatinib (Gleevec). Be sure to label the players. (4 points)

3. Polycythemia vera, essential thrombocythemia, and primary myelofibrosis are all disease that are BCL-ABL negative myeloproliferative neoplasms (MPNs). Name the one drug treatment they all have in common. (2 points)
Ron Bose Proteomics and MS (11 points)

1. What is the difference between B-ions and Y-ions with respect to mass spectrometry? (1 point)

2. What are two ways to enrich a protein of interest for mass spectrometry? (2 points)

3. What are 3 limitations of Difference Imaging Gel Electrophoresis (DIGE)? (3 points)

4. What is the main limitation of 2-D gel electrophoresis? (1 point)

5. What enzyme is commonly used to digest peptide sequences for mass spectrometry? At what residues does it cleave? (2 points)

6. How do 2-D gel electrophoresis and Difference Imaging Gel Electrophoresis (DIGE) differ? (2 points)