1) Basic Lab Skills
   A. Conceptual understanding and moderate level of hands-on proficiency in making laboratory solutions, including understanding different measures of concentration and the required mathematical calculations.
      i. Perform calculations for making multicomponent solution with different concentration values—summative
      ii. Achieve moderate proficiency—formative

   B. Conceptual understanding of how a pH buffer works.
      i. Select appropriate buffer compound for target pH—summative
      ii. Use Henderson-Hasselbalch to calculate proton acceptor/donor ratios—summative

   C. Moderate level of hands-on proficiency in pipetting.
      i. Achieve moderate proficiency—formative (potential for summative lab practical)

   D. Good notebook keeping.
      i. Keep a correctly formatted lab notebook of all lab work—summative

2) Protein Purification Techniques
   An in depth conceptual understanding and beginning level of hands-on proficiency in:

   A. Column chromatography
      i. Produce a chromatogram from experimental data/interpret a chromatogram from different types of chromatography—summative
      ii. Select an appropriate column resin for protein purification—summative
      iii. Achieve beginning-level proficiency

   B. Fractionation of cells by centrifugation
      i. Design centrifugation to isolate specific organelles—summative
      ii. Achieve beginning-level proficiency—formative

   C. Fractionation of proteins by ammonium sulfate precipitation
      i. Design/interpret precipitation to fractionate proteins by hydrophobicity—summative
      ii. Achieve high-level proficiency—formative (potential for summative lab practical)

   D. Purification table
      i. Create a purification table from protein purification results (protein assay/enzyme activity assay)—summative
      ii. Interpret a purification table—summative

3) Binding affinity and dissociation constant
   i. Use dissociation constant values to interpret data presented in graphs and tables
4) Electrophoresis
   A. In depth conceptual understanding of the factors that determine how molecules migrate in an electric field.
      i. Understand the factors that determine how molecules migrate in an electric field—summative

   B. In depth knowledge of SDS-PAGE.
      ii. Describe the function of each reagent—summative

   C. Moderate level of hands-on proficiency in running polyacrylamide and agarose gels.
      i. Assemble and load an SDS-PAGE gel—formative (potential for summative lab practical)

   D. Conceptual understanding of protein charge and isoelectric point.
      i. Use isoelectric point to predict how protein net charge will change with pH—summative
      ii. Design an ion exchange chromatography experiment—summative

5) Enzyme Activity Assays
   A) In depth understanding of both qualitative and quantitative methods for determining enzyme activity.
      i. Calculate enzyme activity units from $\Delta A$/minute—summative
      ii. Explain what makes an assay quantitative vs. qualitative—summative

   B. Moderate level of hands-on proficiency in performing these assays.
      i. Perform assay well enough to successfully obtain results—formative/summative

6) Quantifying Total Protein Concentration
   A. Understand how protein concentration is determined by absorbance and colorizing agents.
      i. Explain how Bradford assay works—summative
      ii. Know when to use $A_{280}$ vs. colorizing agent—summative

   B. Moderate level of hands-on proficiency in performing these assays.
      i. Correctly perform Bradford assay/ $A_{280}$ with minimal instruction—formative (potential for summative lab practical)
7) Antibody-Based Techniques for Protein Detection
   A. In depth conceptual understanding of what antibodies are and how they are used as tools in research.
      i. Explain the difference and relative advantages of polyclonal vs. monoclonal antibodies—summative
      ii. Draw the structure of an antibody molecule and point out functional regions—summative
   B. Conceptual understanding of Western blot
      i. Diagram the mechanics of how a Western blot works—summative
      ii. Define chemiluminescence, horseradish peroxidase, and blocking agent and how they are used—summative
   C. Conceptual understanding of ELISA
      i. Diagram competition, antibody capture, and two-site capture ELISA, showing all major components—summative
   D. Introductory level of hands-on proficiency in the above assays.
      i. Perform Western blot and ELISA with instruction in lab—formative

8) Recombinant Proteins
   A. In depth conceptual understanding of what recombinant proteins are, how they are produced in the laboratory, and their relevance to society.
      i. Explain what makes a protein “recombinant” and why recombinant proteins are important—summative
      ii. Apply the Central Dogma of Molecular Biology to delineate the transcribed sequence and the translated sequence of a gene encoding a recombinant protein in a plasmid expression vector—summative
      iii. Explain the important genetic elements of a plasmid expression vector and state the level of the Central Dogma at which they function—summative
   B. Introduction to the theory behind modifying proteins by amino acid substitutions.
      i. Identify amino acid substitutions in aligned protein sequences and define using correct nomenclature—summative

9) Spectrophotometry
   A. In depth conceptual understanding of light absorption and the various applications of spectrophotometry.
      i. Calculate concentration using Beer’s Law—summative
      ii. Explain relationship between wavelength, energy of photon, and magnitude of electronic transition in absorbing compound—summative
      iii. Draw/interpret an absorption spectrum—summative
   B. High level of hands-on proficiency in using spectrophotometry in the laboratory.
      i. Measure protein and DNA concentrations using spectrophotometry—formative (potential for summative lab practical)
10) Bioinformatics (Actual coursework not currently in alignment)

A. Moderate level of proficiency in accessing protein sequences from databases, and in the use of various amino acids sequence analysis tools.
   i. Align protein sequences and identify amino acid substitutions—summative
   ii. Use amino acid sequence analysis tool to predict isoelectric point—formative/summative
   iii. Find gene/protein sequences in NCBI databases using Entrez; obtain and utilize accession number—formative

B. Examine and appreciate protein structures

11) Fluorescent Proteins

A. In depth conceptual understanding of what fluorescent proteins are and how they are used in research.
   i. Provide specific examples of how fluorescent proteins are used in research—summative
   ii. Explain what properties of fluorescent protein are critical for their use in research and how these can be modified by amino acid substitutions—summative

B. Introductory level of understanding of FRET, more advanced fluorescence techniques
   i. Diagram photon absorption/emission and the corresponding electronic transitions to explain how FRET works—summative
   ii. Provide specific examples of how FRET is used in research—summative

C. In depth understanding of fluorescence
   i. Diagram photon absorption/emission and the corresponding electronic transitions—summative
   ii. Explain the relationship between the wavelength of the absorbed/emitted photons and the corresponding electronic transitions

12) Development of Scientific Reasoning Skills

A. Experimental Design and Interpretation; use of controls
   i. Design experiments to answer specific questions that are given—summative
   
   ii. Correctly interpret experimental data in the form of figures and graphs—summative
   
   iii. Define and/or interpret the controls required for an experiment—summative
   
   iv. Develop a hypothesis to explain experimental observations and then develop an experiment to test the hypothesis—summative
B. Develop quantitative reasoning skills
   i. Correctly interpret quantitative data presented in graphs and tables—summative
   
   ii. Create graphs and tables to present quantitative data—summative
   
   iii. Determine significant vs. non-significant differences between samples in data presented in graphs and figure—need to develop this

C. Accessing the reading the scientific literature
   i. Use PubMed searches to find articles—summative
   
   ii. Extract specific information in the form of results and experimental design from reading primary research articles—summative

D. Writing in a scientific format
   i. Write lab reports to convey experimental data and its relevance using the format of the primary research literature—summative
   
   ii. Make effective arguments in writing by using (B) Quantitative reasoning skills and (A) Experimental design and interpretation skills—summative

13) Gain an appreciation for what science is and how it works. Understand the experiment and/or observation-driven acquisition of knowledge.

**Expected Proficiency Upon Entering BIBC 103:**

1) Knowledge of cell and molecular biology equivalent to the successful completion of BILD1.
   A. Central Dogma of Molecular Biology
   B. Basic protein structure; amino acid sequence and general concept of protein folding.

2) Competency in writing English

3) Some knowledge of how to access and read the scientific literature—most important item to be addressed in an intro lab class.
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<td>1B pH buffer</td>
<td>make pH buffer in lab</td>
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<td>1D Lab notebook</td>
<td>keep notebook</td>
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<td><strong>Protein Purification</strong></td>
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<tr>
<td>2A Column chromatography; protein conc. A280</td>
<td>run column chromatography</td>
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<td>2B Centrifugation</td>
<td>fractionate cells by centrifugation</td>
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<td>ammonium sulfate precip.</td>
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<td><strong>General</strong></td>
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<td>5B Enzyme activity assays</td>
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<td>9B Spectrophotometry</td>
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<td>10A Bioinformatics</td>
<td>perform amino acid sequence alignment</td>
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<td>use amino acid sequence analysis tools</td>
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<td>design centrifugation</td>
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<td><strong>Electrophoresis</strong></td>
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<td>4A Factors that determine migration rate</td>
<td>understand these factors</td>
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<td>4B Knowledge of SDS-PAGE</td>
<td>describe function of each reagent</td>
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<td>4C Isoelectric point</td>
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<td>draw IgG structure, functional domains</td>
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</table>
7B Western blot
- diagram mechanics of Western blot
- define chemiluminescence, HRP, and blocking agent
- lab, practice questions C no no yes; exam

7C ELISA (generally not covered fall quarter)
- diagram 3 types of ELISA assay
- practice questions no yes; exam

Spectrophotometry and Spectrophotometry Based Assays
9A Understand light absorption and spectrophot.
- use Beer's Law
- draw and interpret absorption spectrum
- lab, practice questions no yes; exam

5A Enzyme activity assays
- calculate enzyme activity units
- quantitative vs. qualitative assays
- lab, practice questions C yes no no; exam

6A Assays for protein concentration
- explain Bradford assay
- colorizing agent vs. A280
- lab, practice questions no no yes; exam

Recombinant Proteins
8A Understand what they are, how produced, and relevance to society
- explain what makes a protein recombinant and why this is important
- lab, practice questions no yes; exam

Fluorescent Proteins
11A Understand what they are and how they are used in research
- provide examples of how they are used in research
- practice questions no yes; lab report

Scientific Reasoning Skills
12A Experimental design and interpretation
- interpret data in the form of figures and graphs
- design experiments to answer designated questions
- define and/or interpret controls required for an experiment
- develop hypothesis from experimental observations and design experiment to test it
- practice questions no no E no E; lab report, exam

12B Develop quantitative reasoning skills
- interpret quantitative data in graphs and tables
- create graphs and tables to present quantitative data
- determine significant vs. non-significant differences between samples in data presented in graphs/figures
- lab, practice questions B no yes; exam, lab report

12C Accessing and reading the scientific literature
- use PubMed to find articles
- extract results and/or experimental design from reading primary research articles
- lab, practice questions no yes; lab report

12D Writing in a scientific format
- write lab reports to convey experimental data and its relevance using primary research article format
- lab, practice questions yes B yes; lab report
Assessment Key

Multiple, low risk assignments
Guidance from TA/instructor during exercise
Stated as a learning objective in practice problems, but no practice problems given
Sufficient practice questions not now supplied
In development; new project