

Biotechnology: A Laboratory Skills Course

Second Edition

Correlation Table for the Biotechnology Assistant Credentialing Exam

Key: **ACTIVITIES, VIGNETTES**

Biotechnology: A Laboratory Skills Course, Second Edition provides background content and activities that support student learning in the biotechnology topics and skills assessed on the Biotechnology Assistant Credentialing Exam (BACE) from Biotility. Below is a correlation table describing how and where each topic is addressed in the student text.

Visit bio-rad.com/textbook for more information about *Biotechnology: A Laboratory Skills Course, Second Edition* and the Biotechnology Assistant Credentialing Exam.

Biochemistry

Topic	Location of content in <i>Biotechnology: A Laboratory Skills Course</i>	Content includes the following
Bonds	Not specifically addressed. Primarily covered in a chemistry course	Brief mention of hydrogen bonding in the context of DNA base pairing
Cellular Respiration	Not addressed. Primarily covered in a general biology course	—
Chemistry, Molecules, and Macromolecules	Not fully addressed. Primarily covered in chemistry and general biology courses. Protein structure and function is explained in chapter 7.	—
DNA Structure and Function	4.1 Molecular Biology <i>The Central Dogma of Molecular Biology</i> 4.2 DNA Structure 7.1 Protein Synthesis <i>Bacterial Transcription, Eukaryotic Transcription</i>	The role of DNA in the central dogma of molecular biology; the molecular structure of DNA; transcription
Enzymes and Reactions/ Reaction Rates	7.3 Proteins in Biology <i>Globular Proteins</i> <i>Enzymes</i> 7.E Biofuel Enzyme Assay	The function of enzymes as catalysts, including the theory of induced fit A laboratory activity to measure reaction rates with enzymes

Protein Structure and Function	7.2 Protein Structure 7.3 Proteins in Biology 7.4 Proteins in Biotechnology ACTIVITIES: 7.B Size Exclusion Chromatography 7.C GFP Purification by Hydrophobic Interaction Chromatography 7.D SDS-PAGE of Fish Muscle 7.E Biofuel Enzyme Assay	The four levels of protein structure Four laboratory activities requiring students to analyze experimental evidence to draw conclusions about protein structure and function
Transcription	7.1 Protein Synthesis <i>Bacterial Transcription, Eukaryotic Transcription</i>	Descriptions of the processes of both bacterial and eukaryotic transcription
Translation (Gene Expression)	7.1 Protein Synthesis <i>Translation, Posttranslational Modifications</i>	The process of mRNA processing and translation, and a brief mention of posttranslational modifications

Cells

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Cells (General)	3.1 Microbiology and Cell Biology 3.2 Bacteria 3.6 Eukaryotic Cells	Koch's postulates and the role of microbes in health Descriptions and definitions of the primary structural elements of bacteria and eukaryotic cells
Structure, Organelles, and Function	3.2 Bacteria 3.6 Eukaryotic Cells	Descriptions and definitions of the primary structural elements of bacteria and eukaryotic cells

Laboratory Skills/Applications

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Cell and Tissue Culture/Aseptic Technique	3.4 Culturing Bacteria in the Laboratory 3.8 Eukaryotic Cell Culture ACTIVITIES: 3.A Making Microbiology Media 3.B Disk Diffusion Test (Modified Kirby-Bauer Test) 3.C Microbes and Health: An Illustration of Koch's Postulates 3.E Quantifying Bacterial Numbers VIGNETTES: How to...Use Aseptic Technique to Transfer Bacteria	Descriptions of the techniques used in culturing bacteria and eukaryotic cells, including the types of media used Four laboratory activities for students to practice bacterial culture techniques and aseptic technique



Chromatography	<p>7.5 Methods of Protein Analysis <i>Protein Chromatography</i></p> <p>ACTIVITIES: 7.B Size Exclusion Chromatography 7.C GFP Purification by Hydrophobic Interaction Chromatography</p>	<p>Describes protein purification chemistry and processes in laboratories and industry; explains four chromatography modes: size exclusion, ion exchange, affinity, and hydrophobic interaction</p> <p>Three laboratory activities for students to practice chromatography techniques</p>
DNA Isolation	<p>5.3 Plasmid Purification and Quantitation</p> <p>ACTIVITIES: 2.A DNA Extraction and Precipitation 5.C Purification of S3 and pGLO Plasmids</p>	<p>Description of plasmid purification</p> <p>Two laboratory activities for students to practice DNA extraction and purification</p>
Electrophoresis	<p>4.4 DNA Analysis Techniques 7.5 Methods of Protein Analysis <i>Protein Electrophoresis, Other Types of PAGE</i></p> <p>ACTIVITIES: 4.C Dye Electrophoresis 4.D Restriction Digestion and Analysis of Lambda DNA 4.E Forensic DNA Fingerprinting 5.D DNA Quantitation 6.A STR PCR Analysis 6.B GMO Detection by PCR 6.C Detection of the Human PV92 Alu Insertion 6.D Fish DNA Barcoding 7.D SDS-PAGE of Fish Muscle</p>	<p>Descriptions of the general chemistry and physics of electrophoresis as well as the techniques, equipment, and applications of both DNA and protein electrophoresis</p> <p>Nine laboratory activities for students to practice horizontal DNA gel electrophoresis and one activity for vertical protein gel electrophoresis</p>
Microscopy	<p>3.8 Eukaryotic Cell Culture <i>Visualization</i></p> <p>ACTIVITIES: 3.C Microbes and Health: An Illustration of Koch's Postulates 3.D Gram Staining</p>	<p>Brief description of light and fluorescent microscopy</p> <p>Two laboratory activities for students to practice light microscopy</p>
pH	<p>2.3 Laboratory Equipment <i>Measuring pH</i></p> <p>ACTIVITIES: 2.E Titration 2.D Making Solutions</p>	<p>Description of the chemistry of pH and the equipment used to measure pH</p> <p>Two laboratory activities for students to practice measuring pH</p>



Polymerase Chain Reaction (PCR)	<p>Chapter 6 The Polymerase Chain Reaction</p> <p>ACTIVITIES: 6.A STR PCR Analysis 6.B GMO Detection by PCR 6.C Detection of the Human PV92 Alu Insertion 6.D Fish DNA Barcoding</p>	<p>Detailed description of the biochemistry and process of PCR and the equipment used for PCR</p> <p>Instructions on how to set up a thermal cycler and perform PCR</p> <p>Considerations when setting up a PCR reaction</p> <p>Four laboratory activities for students to practice doing PCR</p>
Protein Applications	<p>1.2 Who Uses Biotechnology? 7.4 Proteins in Biotechnology</p>	<p>Descriptions of the uses of proteins in industry, healthcare, research, and various other applications</p>
Recombinant DNA/Cloning	<p>4.3 Recombinant DNA Technology</p>	<p>Brief descriptions of standard recombinant technologies, including restriction enzymes and ligases, as well as advanced techniques, including CRISPR-Cas9, Golden Gate</p> <p>Assembly, Gibson Assembly, and TOPO (TA) Cloning</p>
Restriction Enzymes	<p>4.3 Recombinant DNA Technology <i>Restriction Enzymes</i></p> <p>ACTIVITIES: 4.A Restriction Site Prediction Using NEBcutter 4.D Restriction Digestion and Analysis of Lambda DNA 4.E Forensic DNA Fingerprinting</p>	<p>Describes the discovery, function, and applications of restriction enzymes. Includes 3 activities that use restriction enzyme digestion</p> <p>Three laboratory activities for students to practice using restriction enzymes and interpreting results</p>
Scientific Notation	<p>2.4 Numerical Data <i>Scientific Notation</i></p>	<p>Instructions and examples for using scientific notation</p>
Significant Figures	<p>2.4 Numerical Data <i>Scientific Notation</i></p>	<p>Instructions and examples for using significant figures</p>
Spectrophotometry	<p>3.5 Microbiological Techniques <i>Quantifying Bacteria, Optical Density of Bacteria</i> 5.3 Plasmid Purification and Quantitation <i>DNA Quantitation</i> 7.5 Methods of Protein Analysis <i>Protein Quantitation</i></p> <p>ACTIVITIES: 3.E Quantifying Bacterial Numbers 5.D DNA Quantitation 7.A Protein Quantitation Using the Bradford Assay 7.E Biofuel Enzyme Assay</p>	<p>Description of Beer's Law and the application of spectrophotometry for the quantitation of DNA and protein in samples</p> <p>Four laboratory activities for students to practice spectrophotometry</p>



Transformation and Transfection	5.2 Transforming Cells	Descriptions of the discovery, chemistry, and process of bacterial plasmid transformation
	ACTIVITIES: 5.A Bacterial Transformation with S3 Plasmid 5.B Bacterial Transformation with pGLO Plasmid 5.C Purification of S3 and pGLO Plasmids	Description of the process of transfection and the required equipment Three laboratory activities for students to learn and practice bacterial transformation
Western Blotting and ELISA	8.3 Immunoassays Western Blotting	Description of the principles of western blotting
	ACTIVITIES: 8.D Western Blotting	A laboratory activity for students to run a western blot

Research and Scientific Method

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Experimental Design	9.2 Student Research Projects	Guidelines with examples for designing effective experiments, including conducting background research, selecting appropriate methods, using controls, and collaborating with experts and mentors
Understanding Scientific Method	9.1 What Is Research?	Explanation of the role of research in the discovery of scientific knowledge, how research is conducted, and the differences between deductive and inductive research
Analyzing and Interpreting Results	9.2 Student Research Projects	Instructions and examples of data analysis, including calculating basic statistics and how to draw conclusions from statistical data

General Topics in Biotechnology

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Applications	1.2 Who Uses Biotechnology?	Brief descriptions of numerous fields and industries that use biotechnology
Benefit to Society	1.2 Who Uses Biotechnology?	Brief descriptions of the benefits of biotechnology to society across multiple fields
Biotech Careers	1.7 Careers in Biotechnology Careers in Biotech vignettes	Brief descriptions and real examples of both laboratory and non-laboratory careers in biotechnology Nine vignettes, examples of careers in biotechnology



Ethics	Bioethics vignettes	Nine vignettes, examples of bioethical questions relating to uses of biotechnology
Genetics	ACTIVITIES: 6.A STR PCR Analysis 6.C Detection of the Human PV92 Alu Insertion	Two laboratory activities for students to study human genetics
Immunology	Chapter 8 Immunological Applications	Description of the human immune response and the role of antibodies
Manufacture of Biopharmaceutical Products	1.2 Who Uses Biotechnology? <i>Healthcare, Protein-Based Drug Production</i> 1.3 The Biotechnology Industry <i>Biotechnology Product Development</i> 1.5 Industry Practices 7.6 Protein Production in Industry	Descriptions of the processes and unique requirements of manufacturing protein products and the roles of the quality control and quality assurance departments
Regulatory	1.4 Governmental Regulation of Biotechnology	Descriptions of the organizations in the United States that regulate the biotechnology industry and research
Workplace	1.6 Biotechnology Company Structure 1.7 Careers in Biotechnology	Examples of the primary departments in a biotechnology company and brief descriptions of their roles

Applied Mathematics in Biotechnology

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Density	Not addressed. Primarily covered in a chemistry course	—
Graphing: Beer's Law Standard Curves Axis Scaling and Limits Plotting Data	3.5 Microbiological Techniques <i>Quantifying Bacteria, Optical Density of Bacteria</i> 5.3 Plasmid Purification and Quantitation <i>DNA Quantitation</i> <i>Gel Quantification,</i> <i>Spectrophotometric Quantitation</i> 7.5 Methods of Protein Analysis <i>Protein Quantitation</i> <i>Bradford Assay</i> 9.2 Student Research Projects <i>Data Analysis</i> ACTIVITIES: 3.E Quantifying Bacterial Numbers 5.D DNA Quantitation 7.A Protein Quantitation Using the Bradford Assay 7.E Biofuel Enzyme Assay 8.C Quantitative ELISA	Examples of plotting data in multiple contexts, including Beer's Law, creating and using standard curves, and adjusting axes Five laboratory activities for students to practice graphing skills



Biotechnology Skills

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Autoclaving	2.3 Laboratory Equipment <i>Disinfecting and Sterilizing</i> <i>Autoclaving</i> ACTIVITIES: 3.A Making Microbiology Media	Brief description of autoclaving as a method for sterilizing equipment and reagents A laboratory activity that includes an opportunity for students to practice using an autoclave
Culturing Organisms	3.4 Culturing Bacteria in the Laboratory 3.8 Eukaryotic Cell Culture ACTIVITIES: 3.B Disk Diffusion Test (Modified Kirby-Bauer Test) 3.C Microbes and Health: An Illustration of Koch's Postulates 3.E Quantifying Bacterial Numbers 5.A Bacterial Transformation with S3 Plasmid 5.B Bacterial Transformation with pGLO Plasmid 7.C GFP Purification by Hydrophobic Interaction Chromatography	Descriptions of how to culture bacteria and eukaryotic cells in multiple culture formats, including brief descriptions of media types Six laboratory activities for students to practice culturing bacteria on solid and in liquid media
Aseptic/Sterile Technique, Sterilization	2.3 Laboratory Equipment <i>Disinfecting and Sterilizing</i> 3.5 Microbiological Techniques <i>Aseptic Technique</i> 3.8 Eukaryotic Cell Culture <i>Sterility</i> ACTIVITIES: 3.B Disk Diffusion Test (Modified Kirby-Bauer Test) 3.C Microbes and Health: An Illustration of Koch's Postulates 3.E Quantifying Bacterial Numbers 5.A Bacterial Transformation with S3 Plasmid 5.B Bacterial Transformation with pGLO Plasmid 7.C GFP Purification by Hydrophobic Interaction Chromatography VIGNETTES: How To... Use Aseptic Technique to Transfer Bacteria	Descriptions of multiple methods for sterilizing equipment Instructions for using basic aseptic technique when working with bacteria Six laboratory activities for students to practice aseptic technique when working with bacteria

Electrophoresis	<p>4.4 DNA Analysis Techniques 7.5 Methods of Protein Analysis <i>Protein Electrophoresis, Other Types of PAGE</i></p> <p>ACTIVITIES: 4.C Dye Electrophoresis 4.D Restriction Digestion and Analysis of Lambda DNA 4.E Forensic DNA Fingerprinting 5.D DNA Quantitation 6.A STR PCR Analysis 6.B GMO Detection by PCR 6.C Detection of the Human PV92 Alu Insertion 6.D Fish DNA Barcoding 7.D SDS-PAGE of Fish Muscle</p>	<p>Background information on the chemistry and physics of agarose and polyacrylamide electrophoresis</p> <p>Descriptions of equipment and reagents used in gel electrophoresis</p> <p>Nine laboratory activities for students to learn and practice both horizontal and vertical gel electrophoresis</p>
Liquid Measurement and Pipetting (Macro and Micro)	<p>2.3 Laboratory Equipment <i>Measuring Volumes</i></p> <p>ACTIVITIES: 2.B Pipetting 2.C Kool-Aid Column Chromatography 2.D Making Solutions 2.E Titration</p> <p>VIGNETTES: How To...Use an Adjustable-Volume Micropipet</p>	<p>Directions for using micropipets and other glassware, including reading a meniscus</p> <p>Four laboratory activities for students to learn liquid measurement techniques with different glassware and numerous activities for students to practice pipetting</p>
pH	<p>2.3 Laboratory Equipment <i>Measuring pH</i></p> <p>ACTIVITIES: 2.D Making Solutions 2.E Titration</p>	<p>Description of the chemistry of pH and the equipment used to measure pH</p> <p>Two laboratory activities for students to practice measuring pH</p>
Serial Dilution	<p>3.5 Microbiological Techniques <i>Quantifying Bacteria</i></p> <p>ACTIVITIES: 3.E Quantifying Bacterial Numbers 7.E Biofuel Enzyme Assay 8.C Quantitative ELISA</p>	<p>Description of the purpose and general process of serial dilutions</p> <p>Three laboratory activities for students to practice serial dilutions</p>

Laboratory Equipment

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Identifying Glassware	2.3 Laboratory Equipment <i>Measuring Volumes</i> <i>Liquid Containers</i>	Descriptions of different types of volumetric glassware and instructions for use



Proper Usage: Electrophoresis Equipment Spectrophotometer Micropipetors	<p>2.3 Laboratory Equipment <i>Measuring Volumes</i> <i>Micropipets</i></p> <p>4.4 DNA Analysis Techniques <i>Equipment, Running an Agarose Gel</i></p> <p>7.5 Methods of Protein Analysis <i>Protein Quantitation, Protein Electrophoresis</i></p> <p>ACTIVITIES: 3.E Quantifying Bacterial Numbers 4.C Dye Electrophoresis 4.D Restriction Digestion and Analysis of Lambda DNA 4.E Forensic DNA Fingerprinting 5.D DNA Quantitation 6.A STR PCR Analysis 6.B GMO Detection by PCR 6.C Detection of the Human PV92 Alu Insertion 6.D Fish DNA Barcoding 7.A Protein Quantitation Using the Bradford Assay 7.D SDS-PAGE of Fish Muscle 7.E Biofuel Enzyme Assay</p> <p>VIGNETTES: How To...Use an Adjustable-Volume Micropipet</p>	<p>Descriptions of equipment and reagents used in gel electrophoresis</p> <p>Nine laboratory activities for students to learn and practice both horizontal and vertical gel electrophoresis</p> <p>Instructions for using a spectrophotometer for the quantitation of DNA and protein in samples</p> <p>Four laboratory activities for students to practice spectrophotometry</p> <p>Instructions for using micropipets</p> <p>A laboratory activity for students to learn pipetting and numerous activities for students to practice pipetting</p>
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Weighing/Using Balance	<p>2.3 Laboratory Equipment <i>Measuring Mass</i></p> <p>ACTIVITIES: 2.D Making Solutions 3.A Making Microbiology media 4.B Casting Agarose Gels</p>	<p>Basic steps for measuring mass and descriptions of the types of balances typically used</p> <p>Three laboratory activities for students to practice measuring mass</p>
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Preparing Solutions

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Proper Technique	<p>2.5 Preparing Solutions</p> <p>ACTIVITIES: 2.C Kool-Aid Column Chromatography 2.D Making Solutions</p>	<p>Detailed description of how to properly prepare solutions</p> <p>A laboratory activity for students to learn the proper techniques when making solutions and an additional activity for further practice</p>
Volume/Volume Calculations	<p>2.5 Preparing Solutions <i>Percent Solutions</i> <i>Volume per Volume Percent Solutions</i></p> <p>2.C Kool-Aid Column Chromatography 2.D Making Solutions</p>	<p>Instructions for how to calculate volume per volume dilutions</p> <p>Two laboratory activities for students to practice volume per volume calculations</p>



Weight/Volume Calculations	2.5 Preparing Solutions <i>Percent Solutions</i> <i>Mass per Volume Percent Solutions</i> ACTIVITIES: 2.D Making Solutions	Instructions for how to calculate mass per volume dilutions A laboratory activity for students to practice mass per volume calculations
Molarity Calculations	2.5 Preparing Solutions <i>Molar Solutions</i> ACTIVITIES: 2.D Making Solutions 2.E Titration	Instructions for how to calculate molarity Two laboratory activities for students to practice calculating molarity
Dilutions	2.5 Preparing Solutions <i>Percent Solutions,</i> <i>Using Stock Solutions Given in</i> <i>Terms of "x," Molar Solutions</i> ACTIVITIES: 2.D Making Solutions	Instructions for how to perform dilutions and calculate concentrations of diluted solutions A laboratory activity for students to practice performing dilutions and dilution calculations

Workplace Safety and Behavior

Topic	Location of content in Biotechnology: A Laboratory Skills Course	Content includes the following
Identifying Safety Symbols	2.1 Laboratory Safety <i>General Laboratory Safety</i> 2.3 Laboratory Equipment <i>Labeling</i>	Descriptions of the Globally Harmonized System for Hazard Communication and the National Fire Protection Association labeling systems Explanation of the importance of labeling and how to label reagents
Laboratory Safety Protocols	2.1 Laboratory Safety	Descriptions of multiple types of laboratory hazards and how to ensure safety
Understanding Safety Data Sheets (SDS)	2.1 Laboratory Safety <i>General Laboratory Safety</i>	Description of the information contained on a Safety Data Sheet and how the documents are used
Personal Protective Equipment (PPE)	2.1 Laboratory Safety <i>Personal Protective Equipment</i>	Detailed descriptions of personal protective equipment and what PPE is required in laboratories of each biosafety level
Labeling Samples and Product	2.1 Laboratory Safety <i>General Laboratory Safety</i> 2.3 Laboratory Equipment <i>Labeling</i>	Descriptions of the Globally Harmonized System for Hazard Communication and the National Fire Protection Association labeling systems Explanation of the importance of labeling and how to label reagents

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