Instructional Framework

Bioscience
41.0100.00

Domain 1: Basic Lab Skills Instructional Time: 30-40 %	
STANDARD: 8.0 DEMONSTRATE BASIC LAB SKILLS IN THE USE OF EQUIPMENT AND INSTRUMENTATION	
8.1 Use software/hardware for scientific analyses and documentation (e.g., Excel, PowerPoint, Word)	● Spreadsheet usage (data tables, graphing, equations/formulas)
8.2 Identify and demonstrate proper use of laboratory glassware	● Cleaning Protocol ● Choosing for measurement vs. storage ● Disposal of damaged glassware
8.3 Identify and demonstrate proper use of laboratory balances	● Choosing a balance table top vs. analytical ● Choosing units g/mg ● Tare/zero ● Use of weigh boat/paper
8.4 Identify and demonstrate proper use of micropipettes	● Identifying and choosing appropriate micropipette ● Setting volume ● Choosing correct tip ● Differentiating between 1st & 2nd stop
8.5 Identify and demonstrate proper use of spectrophotometers to create a standard curve relating absorbance and concentration	● Choosing Vis vs. UV spec ● Choosing absorbance or transmittance ● Determining wavelength (λ or lambda max) ● Blanking ● Creating standard curve to determine concentration
8.6 Identify, balance, and operate centrifuges	● Balancing single, multiple tubes & arrangements ● Choosing correct rpm/g (gravity) & time
8.7 Describe the purpose of and how to operate an autoclave	● Sterilize using temperature & pressure ● Hazards of misuse ● Checking water levels ● Choosing correct setting for purpose ● Use of sterilization indicator (i.e. tape)
8.8 Describe and operate fume/laminar flow hoods	● Differentiate between the uses of fume & laminar flow hoods ● Indicate the direction of airflow in each ● Cleaning before & after use
8.9 Prepare microscopic specimens and interpret results using appropriate microscopes (i.e., dissecting, compound, digital)	● Wet/dry mount and staining ● Differentiating between simple & differential stains

	• Choosing a microscope based on sample size • Choosing lens for resolving power • Calculating magnification •
8.10 Conduct gram staining and interpret results	• Type & function of each stain, mordant, reagent • Use of oil immersion lens • Differentiating between Gram + & Gram - result based on color
8.11 Identify and demonstrate proper use of hot plate/stirrers	• Use of temperature and stir settings • Recognition of high temperature warning symbol
8.12 Identify and demonstrate proper use of incubators, including shaking incubators	• Determining when to use shaking incubator • Programming temperatures & rpm's
8.13 Identify and demonstrate proper use of water baths and heat blocks	• Setting the temperature • Regulating water level • Use of a microtube float or water bath test tube rack
8.14 Use a pH meter and explain the logarithmic nature of the pH scale	• Identify acid, neutral, base on a pH scale • Associate H+ concentration with the pH and that each whole number change in pH is a difference in concentration by a power of 10. • Calibrate using known pH buffers • Proper storage in buffer
8.15 Perform electrophoresis (e.g., vertical and horizontal)	• Correct orientation of gel • Fill chamber with buffer • Attach the power source, set voltage • Load wells with sample and standard / marker / ladder • Run gel • Staining gel
8.16 Operate a thermal cycler	• Programs temperatures and times
8.17 Perform column chromatography [(TLC) and column chromatography]	• Differentiate types (not thin layer- not column) ; size exclusion, affinity, HIC, ionic • Collect fractions from elutions
STANDARD: 9.0 DEMONSTRATE MICROBIOLOGY SKILLS	
9.1 Maintain lab and equipment hygiene	• Clean lab workspace and equipment with appropriate disinfectant before and after use.
9.2 Identify, prepare, sterilize, dispense, and store media	• Choose proper media type • Calculate solution concentration • Sterilize media using appropriate method (autoclave, filter)

	• Aliquot or pour • Store appropriately (labeled, at correct temperature)
9.3 Identify, propagate, and quantify microorganisms and cells	• Choose appropriate organism • Culture microorganisms in appropriate media • Quantify bacteria through colony/cfu counting or spectrophotometry (OD600)
9.4 Identify techniques for short- and long-term cultures (e.g., stabs, slants, liquid nitrogen, glycerol stocks)	• Choose appropriate media • Determine length of storage • Choose appropriate temperature (decreasing temp, i.e. liquid nitrogen, increases storage time)
9.5 Isolate, maintain, and store pure cultures	• Streak agar plate for isolation, isolate and select a single colony, reculture, and store in appropriate location and temperature.
9.6 Transform and maintain hosts (e.g., E. coli)	• Perform bacterial transformation (pGLO, rainbow plasmids, etc)
9.7 Decontaminate and dispose of equipment, glassware, and biologicals, including disinfection with 0.5% sodium hypochlorite solution and sterilization using the autoclave	• Choose appropriate disposal method • Choose appropriate decontamination method
STANDARD: 11.0 DEMONSTRATE MATERIAL PREPARATION AND STORAGE	
11.1 Calculate and prepare solutions and buffers (e.g., M/V, %M/V, molarity)	• Mass/Volume, % Mass/Volume, Molar solution, Dilution
11.2 Calculate and prepare dilutions, including specific and serial	• C1V1=C2V2 and serial
11.3 Calculate the molar mass of a given compound using a Periodic Table of Elements	• Calculate the molar mass of a given compound using a Periodic Table of Elements
11.4 Label and store solutions and buffers (e.g., initials, dates, concentration, lots, storage conditions, sterility, hazards, special directions)	• Label and store solutions and buffers (e.g., initials, dates, concentration, lots, storage conditions, sterility, hazards, special directions)
11.5 Use scientific sources to find appropriate solution preparation protocols	• Use scientific sources to find appropriate solution preparation protocols
11.6 Explain the control inventory process for materials and supplies	• Add items to inventory as received with date indicated
STANDARD: 14.0 DEMONSTRATE SCIENTIFIC MEASUREMENTS	
14.1 Perform biomath calculations and solve problems using scientific notation	• Perform biomath calculations and solve problems using scientific notation
14.2 Utilize appropriate SI (International System of Units) base units and prefixes for all measurements (e.g., milli, micro, nano)	• Utilize appropriate SI (International System of Units) base units and prefixes for all measurements (e.g., milli, micro, nano)
14.3 Construct, interpret, and apply graphs using software tools	• Construct, interpret, and apply graphs using software tools

14.4 Perform appropriate statistical analysis (e.g., mean, median, mode, range, standard deviation, and linear regression)	• Perform appropriate statistical analysis (e.g., mean, median, mode, range, standard deviation, and linear regression)

Domain 2: DNA and Protein Technology **Instructional Time: 25-35 %**	
STANDARD: 10.0 DEMONSTRATE PROTEIN TECHNIQUES	
10.1 Compare and contrast methods to detect specific proteins (e.g., Western Blot and ELISA)	• Antibody/Antigen interactions
10.2 Extract and precipitate proteins from cells	• Extract and precipitate proteins from cells • A common method is use of a detergent like SDS / laemmli
10.3 Separate and characterize proteins (e.g., column chromatography, SDS-PAGE)	• Characteristics of amino acids (hydrophilic, hydrophobic, acidic, basic) • Protein structure (primary, secondary, tertiary, quaternary)
10.4 Perform protein assays (i.e., Bradford and Lowry methods)	• Qualitative or quantitative determination of protein concentration
STANDARD: 12.0 DEMONSTRATE THE USE OF BIOINFORMATIC RESOURCES	
12.1 Access DNA and protein databases for sequence analysis (NCBI)	• Access DNA and protein databases for sequence analysis (NCBI)
12.2 Predict origin and function of unknown sequences (NCBI)	• Predict origin and function of unknown sequences (NCBI)
12.3 Retrieve and compare homologous sequences (BLAST)	• Retrieve and compare homologous sequences (BLAST)
12.4 Determine the relationship among multiple sequences (i.e., DNA subway, NCBI, MEGA)	• Determine the relationship among multiple sequences (i.e., DNA subway, NCBI, MEGA)
12.5 Access and interpret gene and genome maps (i.e., FlyBase, NCBI, genome.org)	• Access and interpret gene and genome maps (i.e., FlyBase, NCBI, genome.org)
12.6 Identify genetic variations (e.g., SNP, inversion, translocation, copy number variant)	• Identify genetic variations (e.g., SNP, inversion, translocation, copy number variant)
12.7 Explain the function of different types of BLAST searches including E-value interpretation and score	• Explain the function of different types of BLAST searches including E-value interpretation and score
12.8 Utilize protein data bank (RCSB PDB) for protein structure analysis (e.g., structure data for Cn3D, RCSB)	• Utilize protein data bank (RCSB PDB) for protein structure analysis (e.g., structure data for Cn3D, RCSB)
12.9 Design primers and perform electronic PCR	• Design primers and perform electronic PCR
STANDARD: 13.0 DEMONSTRATE NUCLEIC ACID TECHNIQUES	
13.1 Isolate nucleic acids and explain the structure of DNA (e.g., DNA miniprep/plasmid and	• DNA extraction and purification

genomic DNA)	• Linear vs. circular (plasmids and mitochondrial) • Base pairing rules • 5' 3' directionality, antiparallel
13.2 Perform and analyze restriction digests	• Specificity of restriction enzymes • Identification of restriction sites and their relationship to the number of bands and the size of bands
13.3 Perform and explain the process of vertical and horizontal gel electrophoresis (e.g., electrolysis, buffer selection and preparation, gel concentration preparation)	• Differentiate between horizontal and vertical gel electrophoresis and how to choose (DNA/RNA vs. Protein) • Choice of buffer type and concentration • Choice and calculation of gel concentration • anode vs. cathode end of box • Charge of the molecule • Choosing a voltage • *See 8.15 for performance of electrophoresis*
13.4 Prepare a standard curve based on a DNA or protein ladder to estimate DNA length or protein size	• Measure migration distance of DNA bands in relation to ladder
13.5 Identify and troubleshoot common gel electrophoresis errors from a gel image (e.g., punctured well during loading, overloaded well, nuclease contamination, poor separation of bands)	• Punctured well during loading; absence of bands • Overloaded well, duplication of bands in adjacent well • Nuclease contamination; large smear • Poor separation of bands; must run for longer time or increase voltage • Samples running backwards; absence of bands • Incomplete restriction; large smear • Good Source: file: http://res.hmu.edu.iq/Portals/0/Users/Bazhdar/DNA_Troubleshooting.pdf
13.6 Describe DNA sequencing methods, including basic and next-generation, and compare and contrast the advantages and disadvantages of each method	• Describe DNA sequencing methods, including basic and next-generation, and compare and contrast the advantages and disadvantages of each method
13.7 Compare and contrast the method of PCR to cellular process of DNA replication	• PCR ------- Replication • denature ------- helicase • annealing ------- primase • extension/elongation ------- polymerase & ligase
13.8 Optimize and perform PCR protocols	• Design appropriate primers • Determine optimum number of cycles • Determine optimum temperature and time of each cycle
13.9 Perform basic molecular biology techniques. (e.g., transformation and optimized	• Perform bacterial transformation (pGLO, rainbow plasmids, etc)

protein production)	
13.10 Explain gene regulation (e.g., lac operon or trp operon, introns and exons, alternative splicing)	● Explain gene regulation (e.g., lac operon or trp operon, introns and exons, alternative splicing)

Domain 3: Research and Problem Solving Skills **Instructional Time: 15-25 %**	
STANDARD: 3.0 DEMONSTRATE CRITICAL THINKING AND SCIENTIFIC PROBLEM SOLVING SKILLS	
3.1 Identify and use industry-recognized observational methods and skills	● Identify and use industry-recognized observational methods and skills
3.2 Identify and structure tractable, easily managed and controlled questions showing evidence of observation and connection to prior knowledge	● Identify and structure tractable, easily managed and controlled questions showing evidence of observation and connection to prior knowledge
3.3 Develop and test hypotheses utilizing experimental design, distinguishing between controls and variables and use experimental, analytical, and statistical design	● Develop and test hypotheses utilizing experimental design, distinguishing between controls and variables and use experimental, analytical, and statistical design
3.4 Collect, record, and analyze data	● Collect, record, and analyze data
3.5 Support conclusions based on evidence	● Support conclusions based on evidence
3.6 Communicate results of scientific investigations in oral, written, and graphical form	● Communicate results of scientific investigations in oral, written, and graphical form
STANDARD: 4.0 DEMONSTRATE RESEARCH AND INVESTIGATIVE SKILLS	
4.1 Develop and use relevant terminology found in scientific and technical literature	● See vocab list
4.2 Identify and access scientific and technical literature, including patents, peer-reviewed articles, white papers, and technical bulletins, and summarize findings following the structure and convention of a scientific paper	● Identify and access scientific and technical literature, including patents, peer-reviewed articles, white papers, and technical bulletins, and summarize findings following the structure and convention of a scientific paper
4.3 Review scientific and technical literature and produce a literature review	● Review scientific and technical literature and produce a literature review ● Identify the parts of a scientific paper (abstract, introduction, methods, results, discussion, conclusion)
4.4 Evaluate the scientific merit and commercial viability of prior work and its relevance to experimental design	● Evaluate the scientific merit and commercial viability of prior work and its relevance to experimental design
STANDARD: 7.0 UNDERSTAND THE ROLE OF LIVING ORGANISMS IN BIOSCIENCE RESEARCH	
7.1 Identify model organisms used in research	● Model organisms are identified by these characteristics: short lifespan,

	easy to culture, short generation time, etc
7.2 Identify proper use and limitations of living organisms, including alternatives when available	● Identify proper use and limitations of living organisms, including alternatives when available
7.3 Examine local, state, and federal standards of practice for treatment, care, and maintenance of living organisms	● Examine local, state, and federal standards of practice for treatment, care, and maintenance of living organisms
7.4 Identify important cell lines and their uses (e.g., HeLa, CHO)	● Identify important cell lines and their uses (e.g., HeLa, CHO)- see acronym list
7.5 Propagate plant and animal samples used as models (e.g., C. elegans , Arabidopsis/Wisconsin Fast Plants)	● Propagate plant and animal samples used as models (e.g., C. elegans , Arabidopsis/Wisconsin Fast Plants)

Domain 4: Safety and Regulatory Procedures **Instructional Time: 10-15 %**	
STANDARD: 1.0 MAINTAIN A SAFE WORK ENVIRONMENT	
1.1 Identify and wear appropriate lab attire and personal protective equipment (e.g., safety glasses or goggles, lab coat, gloves, closed-toe shoes)	● Identify and wear appropriate lab attire and personal protective equipment (e.g., safety glasses or goggles, lab coat, gloves, closed-toe shoes)
1.2 Identify emergency contacts and practice emergency protocols (e.g., fire procedure, shower safety, eyewash practice, evacuation protocol)	● Identify emergency contacts and practice emergency protocols (e.g., fire procedure, shower safety, eyewash practice, evacuation protocol)
1.3 Apply information from safety data sheets (SDSs) for all chemicals used in the lab (e.g., storage conditions, recommended PPE, first aid)	● Apply information from safety data sheets (SDSs) for all chemicals used in the lab (e.g., storage conditions, recommended PPE, first aid)
1.4 Explain the importance of routine maintenance of equipment and reporting unsafe or non-functioning equipment	● Explain the importance of routine maintenance of equipment and reporting unsafe or non-functioning equipment
1.5 Maintain equipment log (i.e., eye wash, autoclave, laminar flow hood)	● Maintain equipment log (i.e., eye wash, autoclave, laminar flow hood)
1.6 Identify biological, biohazardous, and chemical materials and explain appropriate handling (i.e., body fluids, ethidium bromide, sodium hypochlorite)	● Identify biological, bio-hazardous, and chemical materials and explain appropriate handling (i.e., body fluids, ethidium bromide, sodium hypochlorite) ● Wear appropriate PPE
1.7 Identify and comply with safety signs and symbols	● Refer to Globally Harmonized System (GHS) from OSHA
1.8 Distinguish the characteristics of biosafety levels (e.g., BSL-1 to BSL-4)	● Types of organisms/pathogens used in each level ● Types of PPE used in each level ● Type of facility requirements for each level
1.9 Identify standard operating procedures (SOPs) for monitoring, using, storing, and disposal	● Identify standard operating procedures (SOPs) for monitoring, using,

of biological, biohazardous, and chemical materials	storing, and disposal of biological, biohazardous, and chemical materials
1.10 Identify standard operating procedures (SOPs) for biological, biohazardous, and chemical spills and/or waste, including broken glass	● Identify standard operating procedures (SOPs) for biological, biohazardous, and chemical spills and/or waste, including broken glass
STANDARD: 2.0 DEMONSTRATE STANDARD OPERATING PROCEDURES (SOPS) IN THE LABORATORY	
2.1 Identify and comply with state, local, and industry regulations (e.g., EPA, FDA, OSHA, NIH, AZDEQ)	● Location specific
2.2 Use industry terminology (e.g., cGMP, GLP, SOP, CIP, SIP)	● *See acronym list
2.3 Set up and maintain lab documentation according to standard operating procedures (SOPs) (e.g., paper and/or electronic notebook)	● Legal lab book ● Signed / dated / pen / witnessed
STANDARD: 5.0 DEMONSTRATE ETHICAL AND LEGAL CONDUCT	
5.1 Examine codes of ethics and ethical protocols used by different organizations that apply to confidentiality and security	● Examine codes of ethics and ethical protocols used by different organizations that apply to confidentiality and security
5.2 Identify behaviors and practices that could result in liability or negligence	● Identify behaviors and practices that could result in liability or negligence
5.3 Examine implications of bioethical issues (e.g., the use of GMOs, the HeLa privacy issue)	● Bioethics ● Identification of stakeholders
5.4 Apply risk management protocols to incident reporting	● Apply risk management protocols to incident reporting
5.5 Comply with legal, regulatory, and accreditation standards or codes	● Comply with legal, regulatory, and accreditation standards or codes
5.6 Adhere to standards for harassment, labor, and employment laws (e.g., EPA, FDA, OSHA, NIH, AZDEQ)	● Adhere to standards for harassment, labor, and employment laws (e.g., EPA, FDA, OSHA, NIH, AZDEQ)
STANDARD: 6.0 DEMONSTRATE QUALITY CONTROL PROCEDURES	
6.1 Perform quality tests on reagents prepared or used in the lab to ensure reproducibility (i.e., pH, conductivity, spectrophotometry)	● Perform quality tests on reagents prepared or used in the lab to ensure reproducibility (i.e., pH, conductivity, spectrophotometry)
6.2 Document results of quality testing by following standard operating procedures (SOPs)	● Use legal lab notebook or industry-approved, trackable electronic
6.3 Describe manufacturing practices pertaining to quality control (QC) (e.g., standards and control chart ramifications)	● Following SOPs ● Testing according to criteria
6.4 Demonstrate reproducibility from an SOP and characterize variation across samples (i.e., trend analysis)	● Relationship between quality control and quality assurance