



HIGH SCHOOL ADVANCED BIOTECHNOLOGY

ACADEMIC & PROFESSIONAL SKILLS STANDARDS

CATALINA FOOTHILLS SCHOOL DISTRICT

Approved by the Governing Board
April 27, 2021

CATALINA FOOTHILLS SCHOOL DISTRICT
HIGH SCHOOL ADVANCED BIOTECHNOLOGY OVERVIEW
GRADE 12

High School Advanced Biotechnology is a dual enrollment advanced laboratory course that emphasizes the role that biotechnology plays in research and industry. Students will apply previously developed knowledge and skills in biotechnology to an industry-based laboratory setting. The course utilizes the foundations of chemistry, biology, and biotechnology to study current issues in the field. Topics of study include bioethics, organisms in biotechnology, genetic engineering, and development of biotechnology products. Emphasis on laboratory practices, along with independent research, will culminate in a self-selected research project that will be presented by the student in a scientific environment. Options for internships in the community along with guided research mentors will enable students to apply their skills in a biotechnology lab. Students will conduct challenging experiments including isolation of muscle protein, DNA screening, designing and using PCR primers, completing microarrays to determine the differences between cancer and normal cells, and advanced isolation work using a variety of gel electrophoresis techniques.

Optional summer internship opportunities are available for students who wish to continue performing scientific research. Students who are interested in earning college credit for UA MCB 102 must register and pay reduced tuition to the University of Arizona. Scholarships are available from Pima JTED. See course instructor for more information.

The standards for high school Advanced Biotechnology are categorized according to the topics listed below. The list does not imply the instructional sequence or how the standards will be organized for instruction. Educators will make decisions about instructional sequence and how standards will be grouped by units for classroom instruction and assessment to best meet student needs.

High School Advanced Biotechnology Topics:

- Biotechnology
 - Industry Safety Standards
 - Bioscience Research and Bioethics
 - Investigative and Laboratory Skills
 - Bacteria/Microbiology
 - Organisms in Biotechnology
 - Genetic Engineering
 - Independent Research Project
 - Careers in Biotechnology
 - Development of Biotechnology Products
- Arizona Professional Skills (Career & Technical Education)

BIOSCIENCE

STANDARDS FOR ADVANCED BIOTECHNOLOGY

INDUSTRY SAFETY PROCEDURES

- Adhere to health practices and industry safety standards in the classroom and laboratory setting for personal health and safety and the health and safety of others (*i.e.*, SOPs for biological, biohazardous, and chemical materials, appropriate personal protective equipment [PPE] for the situation, emergency equipment).
- Safely operate and perform care and routine maintenance of equipment (*e.g.*, maintain equipment log, report unsafe and nonfunctioning equipment, storage of chemicals, reagents and compounds, and maintenance of equipment).
 - manufacturing practices pertaining to quality control (QC)
 - control inventory process for materials and supplies
- Apply compliancy procedures for state, local, and industry regulations (*e.g.*, OSHA [occupational safety and health administration] SDS [safety data sheets], EPA [Environmental Protection Act], FDA [Federal Drug Administration], NIH [National Institute for Health], AZDEQ [Arizona Department of Educational Quality], safety data sheets [SDSs]) for chemicals.
 - Comply with safety signs and symbols and utilize appropriate lab attire and protective equipment (*e.g.*, safety glasses, gloves).
 - Interpret safety data sheets (SDS) and apply practices for the safe use of hazardous chemicals according to standards from the Occupational Safety and Health Administration, Environmental Protection Agency, Federal Drug Administration, National Institute for Health, and the Arizona Department of Educational Quality.
 - Identify appropriate emergency contacts and perform drills for emergency protocols (*e.g.*, fire procedure, evacuation protocol, hazardous chemical contact).
 - Explain appropriate handling of biological and biohazardous materials and distinguish between the biosafety levels (BSL-1 to BSL-4).
 - Perform and document tests for quality control (*i.e.*, accuracy of balances, concentration of chlorine in bleach, pH, spectrophotometry).

BIOSCIENCE RESEARCH AND ETHICAL CONDUCT (CTE Correlation: 2.2, 4.1-4.4, 5.0-5.6, 7.2, 7.3)

- Summarize findings from scientific and technical literature (*e.g.*, patents, peer-reviewed articles, white papers, and technical bulletins).
 - evaluate the scientific merit and commercial viability of prior work and its relevance to experimental design
- Critically analyze the interaction between biotechnology research and society (*e.g.*, genetically modified foods, cloning, bioterrorism, gene therapy, stem cells, and animal research).
 - compare and contrast attitudes about the use of biotechnology regionally, nationally, and internationally
 - differentiate between moral, ethical, and legal biotechnology issues
- Describe codes of ethics and protocols used by various organizations that apply to confidentiality and security.
- Evaluate the regulatory policies impacting biotechnology research (*e.g.*, use of animals in research, applications of recombinant DNA).
- Adhere to standards for harassment, labor, and employment laws as well as other legal and regulatory codes (*e.g.*, EPA, FDA, OSHA, NIH, AZDEQ).
 - Identify and access scientific and technical literature, including patents, peer-reviewed articles, white papers, and technical bulletins.
 - Concisely summarize findings from scientific papers using relevant terminology while taking care to prevent plagiarism.

- Determine the features of experimental design in prior scientific research that led the research to be successful.
- Explain the implications of bioethical issues for society (e.g., *GMOs and HeLa privacy issue*).
- Describe local, state, and federal standards of practice for treatment, care, and maintenance of living organisms.
- Describe practices (including negligence) that could result in liability and how these situations can be avoided (i.e., *risk management and incident reporting*).

INVESTIGATIVE AND LABORATORY SKILLS

- Apply industry-recognized scientific methods to develop knowledge and understanding of scientific ideas and how scientists study the natural world.
 - ask or respond to scientifically-oriented questions
 - develop a testable question or hypothesis based on evidence of scientific principles, probability and/or modeling appropriate to the scientific domain being investigated
 - identify independent and dependent variables and controls
 - select appropriate tools to collect, record, analyze, and evaluate data
 - analyze data using statistics and graphs (e.g., *Excel and other software*)
 - formulate explanations based on evidence and connect explanations to prior scientific knowledge
 - communicate results and justify explanations
- Apply standard operating procedures (SOPs) in the laboratory.
- Operate lab equipment properly and safely (i.e., *centrifuges, gel electrophoresis apparatus, autoclave, glassware, balances, micropipettes, spectrophotometer, fume hoods, incubators, hot plates, water baths, pH meter, etc.*).
 - Develop and test a research question (scientific process).
 - Design experiments using best practices (i.e., *control groups, constants, multiple trials, adequate sample size, detailed procedure*).
 - Make observations and collect data using industry-recognized methods (i.e., *contemporaneous notebook*).
 - Demonstrate reproducibility from an SOPs (Standard Operating Procedures).
 - Operate lab equipment properly and safely.
 - Analyze data (graphs and statistical analyses) using spreadsheet software (e.g., *Excel*).
 - Explain the implications of the research and how it connects with prior scientific knowledge.
 - Communicate results of experiments with others using representations that include graphs, pictures, and written descriptions.

BACTERIA/MICROBIOLOGY

- Demonstrate microbiology skills such as culturing bacteria and preparing microscopic specimens.
- Explain the differences in types of cultures (i.e., *bacterial, mammalian, tissue vs. cell*).
- Transform and maintain hosts (e.g., *E. coli*).
- Determine what types of living organisms are used in biotechnology research (model organisms, cell lines) and conduct experiments with selected organisms.
- Illustrate different types of microorganisms based on morphology, color, and edge margins.
 - Prepare microscopic specimens and observe using a microscope (i.e., *dissecting, compound, digital*).
 - Maintain lab equipment and practice appropriate hygiene (aseptic technique) in the lab environment.
 - Identify, prepare, sterilize, dispense, and store media.
 - Identify, propagate, and quantify microorganisms and cells.
 - Identify techniques for short and long-term cultures (e.g., *stabs, slants, liquid nitrogen, glycerol stocks*).
 - Isolate, maintain, and store pure cultures.
 - Perform transformation of bacteria.

- Compare and contrast mammalian cell culture, bacterial cell culture, and culture of tissues.
- Determine the best cell lines and/or model organism for experiments and the proper use and limitation of living organisms.

ORGANISMS IN BIOTECHNOLOGY

- Describe the characteristics and life cycles of model organisms used in biotechnology, including bacteria (*e.g.*, *E. coli*), fungi (*e.g.*, yeasts and *Aspergillus*), and animals (*e.g.*, *C. elegans*, fruit flies, and rodents).
- Distinguish between prokaryotic cells, eukaryotic cells, and non-living entities such as viruses.
- Monitor how environmental factors affect the growth of cells and model organisms in the laboratory.
- Apply the basic concepts of cell growth to manipulate cultures under aseptic conditions in the laboratory.
- Perform transformations, including competency, selection, antibiotic resistance, and analysis of transformation efficiency.
- Utilize electrophoresis, chromatography, microscopy and spectrophotometry to identify, separate and draw conclusions about biological molecules.
- Use antibody specificity for antigens to test for the presence of protein (*e.g.*, *ELISA*, *Western Blot*, *antibody staining*).
 - Compare common model organisms used in biotechnology.
 - Describe the primary differences between prokaryotes and eukaryotes.
 - Explain the role that environmental factors have on the effects of cellular growth.
 - Demonstrate aseptic technique while working with model organisms.
 - Describe the process of transformation.
 - Apply the process of selective transformations.

GENETIC ENGINEERING

- Describe the function of DNA, RNA, and protein in living cells and the Central Dogma.
- Demonstrate how the structure of DNA influences its function, analysis, and manipulation.
- Explain the role of enzymes (*e.g.*, *restriction enzymes*, *DNA polymerases*, and *nucleases*) in the production and manipulation of DNA molecules.
- Determine and analyze the effect of qualitative and quantitative changes of specific proteins on cell function.
 - Explain and apply the principles involved in DNA analysis via agarose gel electrophoresis.
 - Identify and troubleshoot common gel electrophoresis errors from a gel image.
 - Isolate genomic and recombinant DNA from cells and solutions and analyze its purity and concentration.
 - Describe prior and current DNA sequencing technologies.
 - Explain the types of BLAST searches, compare homologous sequences using BLAST, and interpret E-values and scores.
 - Utilize protein data bank (RCSB PDB) for protein structure analysis (*e.g.*, *structure data for Cn3D*, *RCSB*).
 - Identify sources of genetic variation (*e.g.*, *SNP*, *inversion*, *translocation*, *copy number variant*).
 - Isolate nucleic acids and explain the structure of DNA.
 - Model how the DNA code is transferred to the ribosome for protein synthesis.
 - Perform PCR in the lab using a thermocycler (*i.e.*, *design primers*, *optimize and perform protocols*).
 - Compare and contrast PCR to the cellular process of DNA replication.
 - Perform and explain the process of vertical and horizontal gel electrophoresis.
 - Prepare a standard curve based on a DNA or protein ladder to estimate DNA length or protein size.
 - Describe DNA sequencing methods, including basic and next-generation, and compare the advantages and disadvantages of each method.

INDEPENDENT RESEARCH PROJECT

- Design and carry out a research project that relates to biotechnology.
- Identify and structure a series of controlled questions showing evidence of observation and connections to prior knowledge.
- Locate and identify appropriate control groups for the project, both positive and negative.
- Synthesize scientific literature to produce a literature review.
- Evaluate the scientific merit and viability of prior work and its relevance to science.
- Present research project with other scientists at a conference (e.g., SARSEF, school science fair).
 - Create a plan for a research project related to biotechnology.
 - Develop a research question to formulate testable conditions.
 - Carry out the investigation in a safe and ethical manner.
 - Use identified tools and/or technologies to generate and analyze data in order to make valid and reliable scientific claims.
 - Maintain a legal scientific notebook of research to follow ethical guidelines.
 - Create an appropriate method to share my work in a formal setting.
 - Present my research at a scientific conference or venue.

CAREERS IN BIOTECHNOLOGY

- Describe the educational requirements and responsibilities for various positions within the biotechnology industry.
- Compare and contrast careers in biotechnology within academic, government, and private sectors.
- Describe the role of student organizations (e.g., HOSA, FBLA, Key Club, and BETA) and their importance in leadership development.
- Explain the nature of employer-employee relationships.
 - Describe the major categories of employment positions within the biotechnology industry.
 - Identify the educational requirements for the primary positions within the biotechnology industry.
 - Describe the knowledge and skills that are necessary for a variety of different opportunities in a biotechnology company.
 - Explain the differences in biotechnology careers found in academia, government, or private sectors.

DEVELOPMENT OF BIOTECHNOLOGY PRODUCTS

- Explain the basis for biotechnology products and how these products affect the quality of life.
- Describe the implications of genomics and proteomics on biotechnology and current healthcare.
 - Describe the major scientific discoveries that lead to development of recombinant DNA technology, including those in the fields of biology, chemistry, genetics, and microbiology.
 - Explain how advances in DNA technology are used today.
 - Identify past and current discoveries and developments in fields such as, agriculture, diagnostics, medical devices, pharmaceuticals, and research and development.
 - Justify the steps in production and delivery of a product made using recombinant DNA technology.

PROFESSIONAL SKILLS: PROFESSIONALISM & ORGANIZATIONAL CULTURE

- Demonstrate professionalism in the workplace (being on time, proper dress, courteousness).
- Represent the school [organization] in a positive manner, demonstrating the school's [or organization's] mission and core values.
- Demonstrate respect for personal and professional boundaries (distinguish between personal and work-related matters).
- Interact respectfully with others; act with integrity.
- Produce high quality work that reflects professional pride and contributes to organizational success.
- Take initiative to develop skills and improve work performance.
 - Communicate the mission and core values of the school [or organization].
 - Follow protocol(s) related to behavior, appearance, and other expectations.
 - Perform my work with a positive attitude.
 - Explain the importance of "dress for success."
 - Demonstrate proper etiquette for introductions with clients.
 - Create work products in a timely manner that are high quality and positively represent the organization.
 - Identify and apply strategies to improve my performance.

PROFESSIONAL SKILLS: COMPLEX COMMUNICATION (TRADITIONAL AND DIGITAL)

- Communicate effectively in a diverse work environment (*i.e., style, format, and medium appropriate to audience/culture/generation, purpose and context; accuracy; use of appropriate technical/industry language; to resolve conflicts; address intergenerational differences/challenges; persuade others*).
- Use documentation (*e.g., itineraries and schedules*) to plan and meet client needs.
- Use appropriate technologies and social media to enhance or clarify communication.
- Use a variety of interpersonal skills, including tone of voice and appropriate physical gestures (for example: eye contact, facing the speaker, active listening) during conversations and discussions to build positive rapport with others.
- Pose and respond to questions, building upon others' ideas in order to enhance the discussion; clarify, verify, or challenge ideas and conclusions with diplomacy.
 - Use appropriate verbal and nonverbal modes of communication.
 - Proof and edit all communications based on [organizational] standards.
 - Verify the accuracy of information and authority of sources.
 - Respond in a timely manner to communications.
 - Address communications in a style that is appropriate to the audience and situation.
 - Use professional etiquette and follow applicable laws and regulations for web-, email-, and social media-based communications.
 - Demonstrate appropriate active listening skills.
 - Ask questions to obtain accurate information.

PROFESSIONAL SKILLS: INITIATIVE AND SELF-DIRECTION

- Apply the skills and mindset of self-direction/self-regulation to accomplish a project.
- Adapt to organizational changes and expectations while maintaining productive and cooperative relationships with colleagues.
- Select and use appropriate technologies to increase productivity.

- Employ leadership skills that build respectful relationships and advance the organization (*e.g., recognize and engage individual strengths, plan for unanticipated changes, pursue solutions/improvements*).
 - Establish priorities and set challenging, achievable goals.
 - Create a plan with specific timelines for completion to achieve the goals.
 - Take initiative to select strategies, resources and/or learning opportunities to accomplish the task(s) in the plan.
 - Identify the success criteria/metrics to determine the effectiveness of the outcome for each goal.
 - Monitor my progress/productivity and self-correct during the learning process.
 - Persist when faced with obstacles or challenges.
 - Reflect upon my learning (strengths and weaknesses) and use feedback to modify work or improve performance.
 - Use appropriate technology tools and resources to create and deliver a product.

PROFESSIONAL SKILLS: CRITICAL THINKING AND INNOVATION

- Identify problems and use strategies and resources to innovate and/or devise plausible solutions.
- Take action or make decisions supported by evidence and reasoning.
- Transfer knowledge/skills from one situation/context to another.
 - Use relevant criteria to eliminate ineffective solutions or approaches and select those that are plausible; put selected alternatives through trials to determine their helpfulness or benefit.
 - Evaluate sources of evidence, the accuracy and relevance of information, and the strengths of arguments.
 - Demonstrate ethical reasoning and judgment by clearly sharing multiple perspectives on why the proposed course of action is ethically the best decision.
 - Identify factors that affect one's objectivity or rationality (*e.g., prejudices, disposition, etc.*).
 - Apply my knowledge and skills in new contexts.

PROFESSIONAL SKILLS: COLLABORATION

- Take responsibility for any role on a team and accurately describe and perform the duties of each role, including leadership.
- Integrate diverse ideas, opinions, and perspectives of the team and negotiate to reach workable solutions.
- Prioritize and monitor individual and team progress toward goals, making sufficient corrections and adjustments when needed.
- Submit high-quality products that meet the specifications for the assigned task.
- Utilize technologies that promote collaboration and productivity, as appropriate.
 - Assess project needs and work with a team in a positive manner to create a final project.
 - Contribute personal strengths to a project.
 - Respect contributions of others.
 - Build team relationships.
 - Proactively solicit feedback; accept and show appreciation for constructive feedback.
 - Act upon feedback to achieve team goals.
 - Critique and reflect on individual and collaborative strengths and weaknesses.
 - Develop a plan for improving individual participation and group productivity.