FUTURELAB+

BIOMED

Nucleic Acids and Proteins: Disease Treatment Innovations

Unit Overview

Developed in partnership with:

Discovery Education and Ignited

BIOMED / NUCLEIC ACIDS AND PROTEINS: DISEASE TREATMENT INNOVATIONS

Unit Overview

FINAL PROJECT PRODUCT

Mystery Disease Conference

OVERVIEW

In this unit, students will focus on the concept of diagnosing and treating diseases. They will explore the role medical devices play in the treatment of patients. For the final unit project, students will create a drug delivery innovation for patients who have been diagnosed with or are at risk for a disease that does not yet have a cure. To complete the unit project, students will use the knowledge they gain from beginning lessons on DNA, RNA, proteins, and how they are modified and isolated, and from later lessons on the phases of drug testing and drug delivery that use mechanisms of nucleic acids and proteins.

STUDENT-FACING UNIT TASK

You are part of a drug research and development team that has been given the opportunity to present at a mock mystery disease conference. You will be introduced to a specific disease that has conventional treatments—but does not yet have a cure—by reading the profile of a patient who suffers from the disease. Your presentation will be given in the style of a PechaKucha: you will prepare 20 slides and discuss each slide for 20 seconds. Your presentation should introduce the audience to the patient and disease and present an innovative drug delivery system or technology that could help to cure or prevent the disease. In your role as a project manager, biomedical technician, clinical researcher, or health information specialist, you will choose a patient profile and work with your group to research the disease with which your patient is diagnosed, including the disease mechanism and the benefits and drawbacks of conventional treatments. Next, using information about nucleic-acid and protein-based treatments from the lessons in this unit, your group will design a potential innovative drug delivery system for the disease. The presentation will include a sketch or animation of how the drug delivery system will work. Finally, your presentation will outline a detailed clinical trial plan to begin the FDA drug approval process. The plan will provide important data about the drug's effectiveness while ensuring equity.

Lesson 1: The Central Dogma of Biology

DRIVING QUESTION

How can you tell the difference between DNA and RNA?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Conduct an experiment to extract DNA. **Explain** the differences between DNA, RNA, and proteins. **Investigate** recombinant drugs that utilize DNA, RNA, or proteins. **Illustrate** the processes of transcription and translation. **CTE:** A3.1, A4.2, A4.3, A9.2	Students will be introduced to careers in the fields of **product development engineering** and **molecular biology.** This lesson focuses on the **discovery** phase of the product life cycle. At this point, researchers would be acquiring more information on the topic of DNA, RNA, and protein recombinant technologies as they seek out a drug delivery method for new pharmaceuticals.	Cardboard Colored pencils DNA Model Build (printout) Glue Large paper (desk or table-sized) Markers DNA and RNA Venn Diagram Protein Synthesis Flow Chart Rubric DNA Protein Illustration Rubric Code for an Animal Instructions Trait Guide Gene Tracker Codon Chart Animal DNA Code Macromolecules as Medicine Capture Sheet Macromolecule Medicine Guide Macromolecule Medicine Rubric Nucleotide Cut-outs DNA, RNA, and Protein foldable Comparative Foldable Rubric Design journal	In this lesson, students will learn about the "central dogma" of biology—how genetic information is perpetuated through RNA and the creation of proteins. DNA and DNA replication is at the center of all biological processes, and by studying these phenomena, students will develop an understanding of disease and advances in medical research and treatments. The unit project will be introduced—students will consider treatment for a disease without a cure. They will consider the mechanism of the disease and treatments and drugs that already exist. With their groups, they will create a device that will improve upon these to cure, prevent, or treat the disease.	Learning about the central dogma provides the scientific basis for recombinant drug delivery. The transformation of genetic information into proteins is at the core of these new technologies, and in turn, must be the basis for new learning on the topic of drug delivery systems. It would be impossible to choose a new drug's delivery method without first understanding the why and how behind that decision.

Lesson 2: DNA Modification

DRIVING QUESTION

How can DNA be intentionally modified to alter the sequence of organisms?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Articulate the structure of DNA used in modification. **Explain** the applications and controversy of CRISPR. **Model** how Cas9 can be used in genetic modification. **Investigate** the ethics of different biotech applications of CRISPR. **CTE:** 5.4, A3.1	Students will be introduced to careers in the fields of **molecular biology** and **biochemistry.** This lesson focuses on the **discovery** phase of the product life cycle as students investigate potential applications of gene editing and CRISPR technology. Only through understanding the essentials of gene manipulation can students hope to ultimately recommend delivery methods for two drug designs.	Internet access Scissors Tape modeling recombinant DNA Bacterial plasmid nitrogen base sequences Human nitrogen base sequences Restriction enzymes Fix the Answer CRISPR paper simulation CRISPR paper simulation student materials Sequencing CRISPR-Cas9 CRISPR Editing in the Body for Blindness What is CRISPR? Why are Doctors So Excited About It? Infographic assignment—CRISPR Technology: Benefits and Concerns Design journal	In this lesson, students will learn how CRISPR technology works, its possible applications, and the ethical dilemmas associated with genomic manipulation. Students will explore how Cas9 (a bacterial RNA-guided endonuclease) works to edit DNA and apply it to the process of CRISPR, investigate the role of women in biotechnology, and explore a multitude of current and potential future applications of genetic manipulation.	As students learn about drug delivery, eventually making their own recommendations on the topic, it is necessary that they have a strong background in genetic modification. The delivery of drugs through modified biological organisms like proteins and nucleic acids may sound dangerous, but better understanding of genetic modification will demonstrate to students that this process is safe and essential to ensuring the health of many.

Lesson 3: DNA Isolation and Purification

DRIVING QUESTION

What are the techniques used to isolate and purify DNA from cells?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Describe how the structure of DNA allows it to be separated by electricity. **Describe** the step-by-step process of DNA extraction. **Conduct** a virtual gel electrophoresis. **Analyze** the results of gel electrophoresis as it applies to paternity, forensic, and evolutionary cases. **Examine** how DNA can be used to prescribe specific medications to patients. **Synthesize** agricultural, medical, and forensic applications in society for DNA extraction. **CTE:** A3.3, A3.5	Students will be introduced to the careers of **laboratory technician** and a **molecular biologist**. This lesson focuses on the **development** phase of the product life cycle as students investigate different techniques of DNA separation.	Highlighters Scissors Examining the Structure of DNA DNA Extraction—virtual lab Restriction enzyme practice Gel Electrophoresis virtual lab Analyzing the Results of Gel Electrophoresis Pharmacogenomics Video Capture Sheet SNP Analysis, Haplotypes and Pharmacogenetics Capture Sheet Biotechnology Applications infographic assignment Design journal	In this lesson, students will review the techniques used to isolate and purify DNA molecules from cells. They will explore tools that are used to cut and separate DNA samples to analyze for medical, agricultural, and evolutionary applications. Students will also understand how DNA helps customize medication and increase a drug's effectiveness.	It is important to understand how DNA can be isolated and purified from cells in order to comprehend how DNA can be used to prescribe specific medications to patients. Scientists can use the structure of DNA to build an understanding of how drugs work on cells and in different parts of the body, and investigate the challenges of getting drugs to specific parts of the body.

Lesson 4: Protein Modification

DRIVING QUESTION

How does modifying a protein change its structure and function?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Identify methods of protein modification. **Apply** knowledge of cell machinery to protein synthesis. **Examine** differences between proteins and enzymes. **Understand** applications of enzymes as drugs and in industrial processes. **CTE:** A3.2, A3.4	Students will be introduced to the careers of **scientific researcher** and **biochemist.** This lesson focuses on the **development** phase of the product life cycle, where personalized medicine and biometric monitoring allow scientists to pinpoint treatments that work for specific patients.	Am I an Enzyme or Not? Capture Sheet Nucleic Acid (DNA), Nucleic Acid (RNA) and Amino Acid foldable Protein assignment Thumbs Up! Capture Sheet Tabletop Texting graphic organizer Enzyme Replacement Therapy—Poster Rubric The Most Interesting Enzyme Presentation Rubric Design journal	In this lesson, students will discuss the various roles of proteins and enzymes within the cells. They will learn how alterations of the DNA sequence can translate into changes in protein conformation and function. Students will examine how these newly synthesized proteins can alleviate symptoms of a disease and possibly cure it.	An understanding of protein synthesis, structure, and function allows us to develop effective medications to treat diseases. Enzymes are already used as drugs and in industrial processes and are a big part of human wellness through pharmaceutical drug design and delivery.

Lesson 5: Protein Isolation and Purification

DRIVING QUESTION

How are human proteins produced and isolated from nonhuman sources?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Explain the significance of protein production and purification. **Describe** the use of various protein isolation techniques. **Outline** the laboratory equipment needed to purify proteins. **List** the various tags used in protein purification. **Investigate** current examples of proteins that are used in humans and isolated from nonhuman sources. **CTE:** A3.4, A5.2, A8.1, A9.1	Students will be introduced to careers in the field of **biochemistry**. In this lesson, as students simulate the product cycle of medicine, they will gain an understanding of why the cycle involves a pyramid, starting with a wide **data collection** process and narrowing down to the **commercialization** of medicine.	Aluminum foil Beads Cotton balls Empty toilet tissue and paper towel rolls Scoring tool Computers Rectangular sheets of bulletin board or poster board Marker Plastic cups Modeling clay Puffballs Paper stars Pipe cleaners Plastic pieces (any shape) Craft stick Cotton swabs Rubber bands Scissors Tape Tissue Toothpicks The Product Cycle of Medicine diagram Diabetes and Insulin tabletop jigsaw activator Methods of Protein Production Capture Sheet Techniques in Protein Production Review Small Group Alternative: Sorting Cards Protein Purification Techniques Video Capture Sheet Protein Purification Lab Tools and Protein Tags Capture Sheet Protein characteristics list Protein Purification Flowchart assignment Protein Purification Flowchart Rubric Protein Purification Lab Manual assignment Protein Purification Lab Manual Rubric Protein Purification Review Nonhuman Proteins Used in Humans assignment Nonhuman Proteins Used in Humans Rubric Design journal	In this lesson, students will learn that biotherapeutics are important applications in biotechnology. Proteins produced using yeast, bacteria, human cells, and other mammalian cells are used as medicines for various chronic and infectious diseases. Insulin is a biotherapeutic protein used to treat individuals diagnosed with Type 1 and Type 2 diabetes. The information in this lesson is an essential part of drug development. Students will play the role of biochemist. The video and simulation will provide students with a virtual view of the processes they would otherwise complete in a laboratory. Students will use the simulation to learn more about purifying proteins. Ultimately, students will investigate examples of proteins used in humans but isolated from nonhuman sources.	Students will gain an understanding of the use of a variety of protein purification methods. They will use this knowledge to explain the advantages and disadvantages of using one purification method over another. Ultimately, this information is essential to know as it must occur prior to a protein being used as a drug.

Lab: Genetic Engineering for Protein Production

DRIVING QUESTION

How can we modify the DNA of an organism to create and isolate a useful protein product?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Perform a bacterial transformation technique to introduce a green fluorescent protein (GFP) gene from a jellyfish into *E. coli* bacteria. **Perform** a protein purification technique to isolate green fluorescent protein from successfully transformed *E. coli* bacteria. **Draw** a scientific model to explain what happens inside a transformed bacteria cell to produce a new protein and how to isolate it. **CTE:** A1.2, A3.1, A3.3, A3.5, A4.3, A8.1, A8.6, A8.7, A9.2, A9.3	In this lab students will play the role of **vaccine researcher**. In the product life cycle, this lab shows that an important step is to determine how best to **modify** a microorganism to **produce** it and then how to isolate and purify it.	Preparing the Classroom for the Lab **(for teacher)** Phenomenon Stations **(two of each)** Background reading: Bacterial Transformation with Gene Regulation **(one per student)** Background reading: Protein Purification **(one per student)** Vocabulary tool: Bacterial Transformation with Gene Regulation **(one per student)** Vocabulary tool: Protein Purification **(one per student)** Student Protocol—Part 1: Bacterial Transformation **(one per group of four)** Student Protocol—Part 2: Protein Purification **(two per group of four)** Student Guide **(one per student)** ** See Unit 3 Lab document for a full list of the reagents, equipment, and consumables for the Part 1: Bacterial Transformation and Part 2: Protein Purification labs.*	In Part 1 of this lab, students genetically engineer *E. coli* bacteria to produce a fluorescent green protein, resulting in glowing bacterial colonies. This is done via a process called "bacterial transformation," in which a GFP (green fluorescent protein) gene originally from jellyfish is introduced into the bacteria. This gene is inducible, meaning that it can be "turned on or off," illustrating the role of gene regulation in protein expression. In Part 2 of this lab, students isolate GFP from successfully transformed *E. coli* colonies using nickel affinity chromatography.	DNA modification and protein isolation/ purification are essential in developing new pharmaceutical drugs. Bacterial transformation and nickel affinity chromatography are simple techniques that demonstrate this.

Lesson 6: Nucleic Acid Assays

DRIVING QUESTION

How are nucleic acid assays used in medicine?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Explain the use of nucleic acids in gel electrophoresis. **Describe** how nucleic acids are used in northern and southern blots and microarrays. **Outline** nucleic acid-based tests used in medicine. **Discuss** how drugs can be made and delivered using nucleic acids. **Identify** scientific data generated using common nucleic acid assays. **CTE:** A3.3, A9.2, A9.3	Students will learn about careers in **molecular biology** and **biochemistry**. They will also learn about the job duties of a **laboratory technician.** In this lesson, students will discover that many therapeutic methods utilize nucleic acids. The **discovery** phase of the product life cycle would include the drug target identification phase.	Aluminum foil Beads One cardboard box per group Construction Paper Cotton balls Glue or tape Pieces of Styrofoam Pipe cleaners Modeling clay Cotton swabs Scissors Toothpicks Laboratory Technique: Gel Electrophoresis Simulation Capture Sheet Nucleic Acid Assays Presentation assignment Nucleic Acid-based Assay Review Nucleic Acid-Based Tests Used in Medicine assignment Nucleic Acid-Based Tests Used in Medicine Rubric Nucleic Acid-Based Drugs Model assignment Nucleic Acid-Based Drugs Model Rubric Nucleic Acid Assay scramble Design journal	In this lesson, students will research nucleic acid-based tests currently used in medicine. As head lab technicians, they will be responsible for being knowledgeable on topics such as when to use a certain nucleic acid assay or how nucleic acid assays can be used as drug targets. Students will learn the basis of gel electrophoresis and how it is used in nucleic acid research. They will also review when to use certain methods of nucleic acid identification. Therapeutic uses of nucleic acids, such as the techniques of RNAi, gene therapy, CRISPR, and antisense, will also be researched. Ultimately, students will create informational material as well as a model of how these tests target the disease.	In this lesson, students will discuss various nucleic acid-based assays used in medicine. This knowledge is essential to their understanding of the laboratory tools used to diagnose and treat different diseases.

Lesson 7: Protein Assays

DRIVING QUESTION

How are protein assays used to make accurate medical or clinical diagnoses?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Obtain, evaluate, and **communicate** background information about the structure and function of proteins and the applications of protein assays. **Describe** how enzyme-linked immunosorbent assay (ELISA) is used to detect the presence of a specific protein in a sample. **Create** a model of ELISA. **CTE:** A3.0, A3.4	Students will learn about the career of **immunologist.** Protein assays exist in the **discovery** phase of the product life cycle as they are used to aid in the discovery of effective treatments and therapies.	Computers with internet access Writing tools Purifying Protein by Column Chromatography virtual lab Kidney Disease PSA assignment Kidney Disease PSA Rubric Interactive ELISA Assay virtual lab Design journal	In this lesson, students will learn that protein assays represent a variety of tests that are used to determine the amount or concentration of a specific protein or groups of proteins. Several types of protein assays are in use today. Proteins, which are one of the four major macromolecules needed to sustain life, are essential to the correct functioning of the cells and tissues of all living organisms. Because of this, protein assays are fundamental to biological research and clinical diagnosis.	The development of protein assays is crucial in the creation and delivery of new treatments and pharmaceutical drugs. The investigative process of how medicines work on cells and different parts of the body would be infinitely more difficult to accomplish without the use of protein assays.

Lesson 8: How Are Drugs Tested?

DRIVING QUESTION

What is the complete process of developing a new medicine from bench to shelf?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Identify and **analyze** the phases of drug testing. **Investigate** current and past drug clinical trials using appropriate databases. **Critique** the ethical dilemmas surrounding particular clinical trial case studies. **CTE:** 5.4, 5.6, A5.1, A7.1, A7.2, A9.1	Students will learn about the careers of **clinical trial coordinator, regulatory documentation scientist,** and **quality engineer.** This lesson focuses on the **development** phase of the product life cycle, which focuses on clinical trial development and implementation. This phase includes a focus on personalized health care and requires collecting and analyzing data from as diverse a population as possible in order to know how well a therapy really works.	Computers with internet access Markers Notecards Poster board Writing tools FDA Summary Time Line Rubric Ball-Toss Debate Drug Discovery Assignment Ball-Toss Debate Drug Discovery Rubric Phases of Drug Approval and Development PowerPoint Rubric ClinicalTrials.gov PowerPoint Rubric Ethics Role Play Video Rubric Design journal	In this lesson, students will learn that constant technological evolution has changed drug design in the past century. New techniques, including computer technology and artificial intelligence, have combined with traditional methods to design more effective new drugs. Some of the steps involved with testing these drugs have remained relatively unchanged, but modern technology has made these testing steps more efficient.	The process of drug design is an important aspect of the use of biotechnology to design products meant for the wellness of individuals, populations, and communities. Communities with high percentages of healthy inhabitants are generally more well off and have more effective community services. Representation of a range of communities in drug development studies and clinical trials ensures the efficacy of the drugs in these communities.

Lesson 9: Mechanisms of Drug Delivery

DRIVING QUESTION

How are nucleic acids and proteins used as pharmaceuticals?

Student Objectives	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Distinguish different features of various drug administration routes. **Investigate** the benefits of proteins and nucleic acids as medicine. **Recommend** drug administration methods based on drug designs. **Critique** drug administration methods based on pain, ease of use, global distribution contributions, and patient monitoring. **CTE:** 5.4, 5.6, A5.1, A9.2, A9.3	Students will learn about the careers of **patent attorney** and **regulatory documentation scientist.** This lesson focuses on the **discovery** phase of the product life cycle. Students will work with the goal of drug route recommendation, which would fall in early clinical development or early clinical trials.	Several sheets of large chart paper Drug Administration sort Drug Administration Anticipation Guide Drug Delivery Systems Capture Sheet Drug Delivery WebQuest Biologics Exit Ticket Which Therapy? Capture Sheet Gene Patenting Argument Gene Patenting Rubric Final project packet Design journal	Students will explore common drug delivery mechanisms, as well as emerging techniques. They will review existing technologies and explore the potential use of nucleic acids and proteins as medicines of the future. The week will culminate with the students working in groups to recommend two drug delivery mechanisms based on a variety of criteria and then presenting their findings.	This lesson is the culmination of the story line. Up until this point, students have been studying the function of DNA and its manipulation, and how to purify and alter biological substances. In this lesson, students will learn about drug administration and current biologics. They will use this information along with prior learning to make administration recommendations for two new drugs.

Career and Technical Education (CTE) Standards

Anchor Standards

5.0 Problem Solving and Critical Thinking
Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the Health Science and Medical Technology sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques. (Direct alignment with WS 11-12.7)

5.4
Interpret information and draw conclusions, based on the best analysis, to make informed decisions.

5.6
Read, interpret, and extract information from documents.

Health Science and Medical Technology Standards

A1.0
Define and assess biotechnology and recognize the diverse applications and impact on society.

A1.2
Describe the use of model organisms in biotechnology research and manufacturing.

A3.0
Demonstrate competencies in the fundamentals of molecular cell biology, including deoxyribonucleic acid (DNA) and proteins and standard techniques for their purification and manipulation.

A3.1
Define and describe the structure and function of DNA ribonucleic acid (RNA) and proteins, and explain the consequences of DNA mutations on proteins.

A3.2
Describe enzyme structure and function, diagram the impact of enzymes and catalysis on reaction rates, and recognize the emerging role of enzymes in replacing industrial chemicals.

A3.3
Employ standard techniques of DNA extraction, purification, restriction digests, bacterial cell culture, and agarose gel electrophoresis and document and evaluate results.

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Career and Technical Education (CTE) Standards

Health Science and Medical Technology Standards

Continued

A3.4
Employ standard protein techniques, including antibody production, enzyme assays, spectrophotometry, gel electrophoresis, and chromatography, and document and evaluate results.

A3.5
Predict outcomes of DNA and protein separation protocols.

A4.0
Recognize basic concepts in cell biology and become familiar with the laboratory tools used for their analysis.

A4.2
Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace.

A4.3
Use various methods to monitor the growth of cell cultures.

A5.0
Integrate computer skills into program components.

A5.1
Use the internet and World Wide Web to collect and share scientific information.

A5.2
Use a variety of methods, including literature searches in libraries, computer databases, and online for gathering background information, making observations, and collecting and organizing data.

A7.0
Understand the function of regulatory agencies for the biotechnology industry and the lasting impact of routine laboratory and communication practices on product development and manufacturing.

A7.1
Identify agencies at the local, state, and federal levels.

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Career and Technical Education (CTE) Standards

Health Science and Medical Technology Standards

Continued

A7.2
Be aware of the role of agencies in promoting patient safety, quality control, and entrepreneurship.

A8.0
Follow sustainable and safe practices with high regard for quality control.

A8.1
Follow written protocols and oral directions to perform a variety of laboratory and technical tasks.

A8.6
Properly and safely use and monitor a variety of scientific equipment, including pH meters, microscopes, spectrophotometers, pipets, micropipettes, and balances.

A8.7
Determine which equipment is appropriate to use for a given task and the units of measurement used.

A9.0
Understand that manufacturing represents inter-connectedness between science and production.

A9.1
Describe the major steps of a product's move through a company's product pipeline.

A9.2
Identify several products obtained through recombinant DNA technology.

A9.3
Outline the steps in production and delivery of a product made through recombinant DNA technology.

Third Party Evaluator Evidence/Findings

Completed by: American Institutes for Research

Sponsored by Genentech, Futurelab+ brings together a coalition of partners to develop an innovative, modular, two-year biotechnology curriculum, including instructional materials, to expose students and educators to the breadth of education and career pathways across biotechnology. To increase adoption and access to such curricula in California and beyond, the modular curriculum was designed to align with the *California Career Technical Education (CTE) Model Curriculum Standards for Biotechnology*, meet at least one year of the *University of California science (D) subject requirement*, and incorporate some of the three-dimensional learning innovations of the *Next Generation Science Standards* (NGSS).

The two-year biotechnology curriculum provides four core units per year; each core unit has nine lessons and a lab that each take approximately one week to complete, or 9–10 weeks for the full unit. In total, the biotechnology curriculum has 72 lessons and eight labs that span two full instructional years. Because the Futurelab+ biotechnology curriculum is modular, teachers can select specific units and materials to design biotechnology courses that are relevant and appropriate for their students and teaching environment.

Unit 3: Nucleic Acids and Proteins: Disease Treatment Innovations

Version Reviewed/Date: March 2, 2022

California (CTE) Model Curriculum Standards for Biotechnology

Full Report

[Futurelab+... priority to meet California CTE Biotech Standards...] Evidence of which California CTE Biotechnology standards are addressed within the curriculum and where they are addressed is included in the *full report*.

University of California Science (D)

Full Report

Because teachers and schools can choose which portions of the curriculum to include in their final course designs, this *report series* provides evidence of where each unit meets specific criteria for the UC science (D) subject requirement and, when incorporated into a full year-long course, where the curriculum could meet at least one year of the UC science (D) subject requirement, contingent upon review and approval by UC. Subsequently, the evidence provided within the report can be used by teachers for submitting Futurelab+ course materials for UC science (D) subject approval.

The purpose of this report is to provide evidence for alignment of Unit 3 of the Futurelab+ Biotechnology Curriculum with the UC science (D) subject requirement. To help educators submit their final courses for UC science (D) subject review, the American Institutes for Research (AIR) also provides a sample unit and lab summaries, which follow the guidelines for writing a UC science (D) course (March 17, 2021).

Specifically, AIR reviewed each unit for evidence of the extent to which they meet the eight Course Content Guidelines for the UC science (D) subject requirement. This report provides specific examples to demonstrate where and how materials satisfy these criteria. Based on our review, we believe there is a strong body of evidence that will translate to Unit 3 meeting the UC science (D) subject matter requirement.

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Third Party Evaluator Evidence/Findings

Continued

Next Generation Science Standards (NGSS)

Full Report

As an organizational partner, the American Institutes for Research (AIR) provided external feedback on alignment to the three sets of standards to Futurelab+ curriculum developers during the formative period of the biotechnology curriculum. AIR is now providing external feedback and evidence on the final curriculum's alignment to each set of standards: CTE, UC science (D) subject requirement, and NGSS in a series of three reports. The eight reports in the NGSS series provide feedback on aspects of NGSS in a sample of the curriculum (one lesson from each unit). AIR randomly selected the Lab (Genetic Engineering for Protein Production) from Unit 3 (Nucleic Acids and Proteins: Disease Treatment Innovations) for this report.

Of note, because the primary design element of the curriculum was alignment to CTE, AIR used the NGSS Lesson Screener (not the Educators Evaluating the Quality of Instructional Products [EQuIP] Rubric) to identify aspects of the curriculum that incorporate NGSS. The EQuIP Rubric is typically used to determine whether a unit was designed for the NGSS. Because the curriculum was designed to align primarily to CTE standards, it was not expected that the curriculum would meet all NGSS criteria. Nevertheless, in their current form, the materials from Unit 3, Lab, met two NGSS criteria and are approaching three NGSS criteria. AIR created the approaching rating to indicate where a modification to materials would increase the rating to adequate. For more information, please see the *full report*.