Subject Matter “D” Evidence: Unit 4, Behind the Scenes of Scientific Breakthroughs

Contents

Executive Summary

Sponsored by Genentech, Futurelab+ brought together a coalition of partners to develop an innovative, modular, 2-year biotechnology curriculum, along with 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 Model Curriculum Standards for Biotechnology, meet at least one year of the University of California (UC) science (D) subject requirement, and incorporate some of the three-dimensional learning innovations of the Next Generation Science Standards (NGSS). The 2-year biotechnology curriculum has four core units per year; each core unit has nine lessons and a lab that each take approximately one week to complete (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 environments, whether they are classroom based, virtual, or hybrid.

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 1 year of the UC science (D) subject requirement, contingent upon review and approval by UC. Subsequently, the evidence provided herein 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 4 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 wrote sample unit and lab summaries, which follow the guidelines for writing a UC science (D) course (March 17, 2021), to provide language to teachers as they write their full course descriptions.

Specifically, AIR reviewed each unit for evidence of the extent to which the unit meets 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 likely translate to Unit 4 meeting the UC science (D) subject matter requirement. **This review was completed on materials received March 24, 2022, and has not been updated to reflect any revisions made to materials since then.**

University of California A–G Course Requirements

To be eligible for admission into the California State University or the University of California (UC) systems, high school students must successfully complete (with a grade of C or better) the UC A through G (A–G) course requirements. The A–G course requirements encompass 15 year-long courses, including (A) 2 years of history/social science, (B) 4 years of English composition and literature, (C) 3 years of mathematics, **(D) 2 years of science**, (E) 2 years of language other than English, (F) 1 year of visual and performing arts, and (G) 1 year of a college preparatory elective. Teachers, parents, and students want high school courses to meet A–G requirements. To increase adoption of the Futurelab+ biotechnology curriculum, the modular curriculum was designed to meet at least 1 year of the UC science (D) subject requirement.

Futurelab+ and UC Science (D) Subject Requirement

The modular, 2-year Futurelab+ biotechnology curriculum consists of four core units each year. Each unit has nine lessons and a lab. A lesson consists of more than one class period of learning to allow students the opportunity to develop their knowledge and understanding more fully. Lessons and labs take approximately five 45-minute instructional periods to complete. In its entirety, the biotechnology curriculum has 72 lessons and eight labs.

The 2-year Futurelab+ biotechnology curriculum was designed to be modular. Teachers can select specific units and materials to design biotechnology courses that are relevant and appropriate for their students and teaching environments. For example, a school or individual biotechnology teacher can create a course that consists of four Futurelab+ units—two units from Year 1 of the curriculum and two units from Year 2 of the curriculum. Meanwhile, a different school or individual biotechnology teacher can create a course that consists of two Futurelab+ units in conjunction with other materials. Each course would have unique course descriptions because the materials are different.

Given the modular nature of the curriculum and because teachers and schools can choose which units to include in their final course designs, this report series provides evidence of where singular units meet 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 1 year of the UC science (D) subject requirement, contingent upon review and approval by UC. Subsequently, the evidence provided herein can be used by teachers for submitting Futurelab+ course materials for UC science (D) subject approval.

To assist educators in writing and submitting to UC their unique course descriptions that incorporate Futurelab+ materials, each unit report includes a sample unit overview, assignment overview, and laboratory activity summary, as required for A–G course submissions and following the sample provided in the UC Policy Guide. **Appendix A** includes the example UC science (D) subject course description provided by UC. **Appendix B** includes a sample unit overview, assignment overview, and laboratory activity for educators to adapt to their needs.

This summary report provides evidence on how **Unit 4, Behind the Scenes of Scientific Breakthroughs**, of the Futurelab+ curriculum meets the UC science (D) subject requirement.

Methodology

There is strong overlap between the UC science course content guidelines and the NGSS Lesson Screener criteria (see Exhibit 1). As such, the American Institutes for Research (AIR) staff first conducted an NGSS Lesson Screener review on a randomly sampled lesson from Unit 4.

Exhibit 1. Course Content Guidelines and NGSS Lesson Screener Criteria

There is strong overlap between the UC science (D) subject requirement and the NGSS Lesson Screener criteria. Specific course content guidelines of the A–G Policy Resource Guide are briefly summarized here, with notations about which Lesson Screener criteria include the same or similar requirements.

- Explicitly integrate the eight NGSS Science and Engineering Practices **(Lesson Screener Criteria B and C); this requirement is mentioned multiple times.**
- Draw content generally from the NGSS **(Lesson Screener Criteria B and C)** and Common Core State Standards for Literacy in History/Social Studies, Science, and Technical Subjects.
- Provide opportunities for students to participate in all phases of the scientific process and require students to discuss ideas with other students **(Lesson Screener Criteria B, C, D, and E).**
- Be explicit about formative and summative assessment practices **(Lesson Screener Criteria B, C, and E).**
- Include real-world problems that engage all students in science learning **(Lesson Screener Criteria A, D, and E).**
- Specify minimum mathematics course requirements.
- Reserve at least 20% of class time for teacher-supervised, hands-on laboratory activities.
- Incorporate technology (to the extent possible) to increase access and computer-based skills for students.

Upon completion of the NGSS Lesson Screener, which looked at Lesson 1, AIR staff reviewed the remaining Unit 4 materials for further evidence of the extent to which the unit meets the following UC science (D) subject matter course criteria, outlined in the Course Content Guidelines:

Criterion 1	Integrate the eight NGSS practices of science and engineering
Criterion 2	Consist of content pulled largely from the California NGSS and the Common Core State Standards for literacy in history/social studies, science, and technical subjects
Criterion 3	Provide opportunities for students to participate in all phases of the scientific process
Criterion 4	Employ quantitative reasoning and methods where appropriate
Criterion 5	Hold at least 20% of class time for teacher-supervised, hands-on laboratory activities
Criterion 6	Include explicit formative and summative assessment practices
Criterion 7	Provide real-world problems and applications
Criterion 8	Include the use of technology if possible

Summary of UC Science (D) Course Content Guidelines

Criterion 1: Integrate the Eight Science and Engineering Practices

Subject "D" Course Criterion 1 requires students to engage with the eight science and engineering practices outlined in the California NGSS throughout a year-long science course. **The following bulleted list shows examples of students engaging with these eight practices throughout Unit 4 of the Futurelab+ curriculum**. The examples are reflections of the practice's definition, they are not necessarily reflections of the developmental progressions of the skills in the practice. This list is not exhaustive.

Practice 1: Asking questions and defining problems

Students engage in elements of *Practice 1, Asking questions and defining problems*, in the following instructional activities:

- **Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions**. In the *Biotech Careers in Longevity Project*, students work in teams, and they play the role of either a project manager, biotechnology researcher, biotech recruiter, or design specialist. As a team, the students must choose one of four scientific breakthroughs as a focus for their research throughout the unit. As the first step in this process, students must research their chosen innovation and identify the problem it was designed to address (Biotech Careers in Longevity Project Design Journal, p. 6).
- **Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory**. In the extension activity for *Longevity Markers: How are you so old?* laboratory investigation, students are asked to formulate a question they still have about the relationship between the specific gene they have been investigating and longevity. Students then design their own follow-up experiment to answer that question. *Note: This activity is included as an optional extension, so it may not be completed by all students.*

Practice 2: Developing and using models

Students engage in elements of *Practice 2, Developing and using models*, in the following instructional activities:

- **Compare models to identify common features and differences**. In the *Cellular Aging* lesson, students view models of an old cell and a young cell and are tasked with creating a presentation that identifies how the two cells differ from each other (Student Section, p. 1).
- **Develop a model to describe unobservable mechanisms**. In the *Senolytics: Our War Against Aging!* lesson, students build three-dimensional models that are used to demonstrate the various causes of cell senescence (Student Section, pp. 1–2).

Practice 3: Planning and carrying out investigations

Students engage in elements of *Practice 3, Planning and carrying out investigations*, in the following instructional activity:

- **Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions**. In the *Longevity Markers: How are you so old?* laboratory investigation, students model the steps in a Genome-Wide Association Study. First, they extract DNA from their own cheek cells and run a gel electrophoresis on their DNA.

Then they use a genetic database to analyze mock genotype data to identify links between genetic SNPs and longevity (Student Section, pp. 59–84).

Practice 4: Analyzing and interpreting data

Students engage in elements of *Practice 4, Analyzing and interpreting data*, in the following instructional activity:

- **Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible**. In the *Longevity Markers: How are you so old?* laboratory investigation, students analyze data from The Human Genome Project to determine whether a specific gene is correlated to longevity. Students are asked to describe a linear regression line for both a gene that *is* associated with the phenotype they are investigating as well as one that is not (Student Section, p. 14).

Practice 5: Using mathematics and computational thinking

Students engage in elements of *Practice 5, Using mathematics and computational thinking*, in the following instructional activity:

- **Apply mathematical concepts and/or processes to scientific and engineering questions and problems**. During the laboratory investigation *Longevity Markers: How are you so old?* students use both a graph and data table to analyze data from a Genome-Wide Association Study to determine if there is an association between a specific gene and longevity (Student Section, pp. 31–33).

Practice 6: Constructing explanations and designing solutions

Students engage in elements of *Practice 6, Constructing explanations and designing solutions*, in the following instructional activity:

- **Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion**. During the *Longevity Markers: How are you so old?* laboratory investigation, students write a "complete Claim, Evidence, Reasoning paragraph that answers the question: is there an association between rs2802288 and longevity?" (Student Section, p. 40).

Practice 7: Engaging in argument from evidence

Students engage in elements of *Practice 7, Engaging in argument from evidence* in Unit 4, including in the following instructional activity:

- **Construct and/or support an argument with evidence, data, and/or a model.** During the *Longevity Markers: How are you so old?* laboratory investigation, students write a "complete Claim, Evidence, Reasoning paragraph that answers the question: is there an association between rs2802288 and longevity?" As the final part of this task, students use scientific principles to explain how their claim is supported by the data they collected (Student Section, p. 40).

Practice 8: Obtaining, evaluating, and communicating information

Students engage in elements of *Practice 8, Obtaining, evaluating, and communicating information*, in several instructional activities, some of which are highlighted below:

- **Communicate scientific and/or technical information or ideas in writing and/or through oral presentation**. In the Day 2 small-group activity of the *Genetic Sequencing* lesson, students work in small groups to research information, using a variety of web sources, to create a public service announcement about disparities in cancer rates for various cultural and ethnic groups (Student Section, p. 5).

- **Communicate scientific and/or technical information or ideas in multiple formats.** For their final project, students investigate a scientific breakthrough in longevity. They must determine the jobs needed to complete the development and implementation of their innovation and create a hiring campaign that includes career profiles, an informational video on their breakthrough, and an interactive hiring board (Biotech Careers in Longevity Project Design Journal, p. 3).

Criterion 2: Content Largely From the California NGSS

As previously noted, the Futurelab+ curriculum was designed to be aligned to the California Career Technical Education Model Curriculum Standards for Biotechnology. These standards, adopted in 2013, include an Academic Alignment Matrix (p. 32) that explicitly indicates content overlap with the NGSS and the Common Core State Standards for Literacy in History/Social Studies, Science, and Technical Subjects. For feedback about incorporation of specific three-dimensional learning and instructional shifts, see the accompanying **Unit 4, Lesson 1, NGSS Lesson Screener** report.

Criterion 3: All Phases of the Scientific Process

Throughout Unit 4, students complete learning activities to develop content knowledge and skills required for the unit's final project, which is to investigate a scientific breakthrough in longevity. Students act as part of a team of researchers that has just made a scientific breakthrough in the field of aging and longevity. In addition to the research required, student teams must determine the jobs needed to complete the development and implementation of their breakthrough and create a hiring campaign that includes career profiles, an informational video on their breakthrough, and an interactive hiring board (Biotech Careers in Longevity Project Design Journal, p. 3). Learning activities that work toward addressing this final project include the following:

- Identifying a longevity innovation and the problem it addresses
- Researching cellular aging, genetic sequencing, The Human Genome Project, synthetic DNA, bioengineering, cloning and stem cell research, ethics in biotechnology, and senolytics
- Communicating what they have learned by creating an introductory video about a longevity scientific breakthrough (In the video, students must define the initial problem and summarize the breakthrough.)
- Identifying the human resources needed to complete the development cycle of the innovation and create a hiring campaign that includes a career snapshot and an interactive job board (Biotech Careers in Longevity Project Design Journal, p. 4)

Student groups are guided through a full 12-step engineering design process to complete this final project, as described in the Biotech Careers in Longevity Project Design Journal (pp. 6–35).

Criterion 4: Employ Quantitative Reasoning and Methods Where Appropriate

Unit 4 has several opportunities for students to use quantitative reasoning, particularly during the laboratory investigation **Longevity Markers: How are you so old?** During this lab, students analyze data from a Genome-Wide Association Study to determine if there is an association between a specific gene and longevity (Student Section, pp. 31–33).

Criterion 5: At Least 20% Class Time for Teacher-Supervised, Hands-On Laboratory Activities

This criterion specifically recommends that at least one scientific investigation be a student-designed project involving a tested hypothesis and that "teacher supervision may be synchronous or asynchronous, depending on whether the learning environment is classroom-based, fully online, or a hybrid."

Names of specific lab activities are noted in the Unit 4 Flow Chart and are listed, along with their timings, below:

- LAB: Longevity Markers: How are you so old?—5 days
- Gene Control Interactive (The Human Genome Project)—1 day
- Final Project Packet (Ethical Consideration and Longevity)—3 days

Unit 4 includes 9 days, or roughly 18% of unit time, of hands-on, teacher-supervised lab activities throughout 50 days of instruction. Although this specific unit does not meet the 20% requirement, the full year of curriculum a student encounters should be taken into consideration for this criterion.

Criterion 6: Explicit Formative and Summative Assessment Practices

AIR found evidence of several opportunities for teachers to gauge student learning, with both formative and summative assessment practices, and students are often provided the opportunity to demonstrate their learning of a specific topic in multiple ways.

The Protocols for Culturally Responsive Learning and Increased Student Engagement include multiple protocols for gathering *formative* assessment information, in a culturally responsive way, about student prior knowledge. Specific protocols and their purposes are often identified within the teaching section, with notes to teachers about what to look for in student responses. An example can be found in Lesson 2, Genetic Sequencing, where teachers can use the *Raise a Righteous Hand* strategy as a formative assessment of initial student ideas and understanding (Teacher Section, p. 5).

The Unit 4 Flow Chart provides an overview for teachers about specific instructional activities and resulting student artifacts generated to demonstrate student learning, including student-created posters, presentations, videos, concept maps, activities, and letters. Each lesson includes several graphic organizers and worksheets for students as well.

Finally, the overall summative assessment is a unit-long, project-based learning opportunity in which students investigate a scientific breakthrough in longevity. Students must determine the jobs needed to complete the development and implementation of their breakthrough and create a hiring campaign that includes career profiles, an informational video on their breakthrough, and an interactive hiring board (Biotech Careers in Longevity Project Design Journal, p. 3).

Criterion 7: Real-World Problems and Applications

Unit 4 of the Futurelab+ biotechnology curriculum excels at providing real-world problem and application connections for students.

As noted in several prior criteria, the Unit 4 final activity is a project-based learning opportunity in which students investigate a scientific breakthrough in longevity. Students determine the jobs needed to complete the development and implementation of their breakthrough and create a hiring campaign that includes career profiles, an informational video on their breakthrough, and an interactive hiring board (Biotech Careers in Longevity Project Design Journal, p. 3). Additionally, lessons within the unit are explicitly tied to real-world problems and scenarios. Some examples of real-world problem and application activities in Unit 4 lessons include the following:

- *Genetic Sequencing*, in which students examine how technology is used to sequence a human genome and health disparities and ethical questions associated with genetic sequencing.
- *The Human Genome Project*, in which students learn about the genome and proteome and how modifying the DNA sequence can affect protein function.
- *Can an Organism Have No Parents?* in which students explore how synthetic DNA can be used to alter traits, treat disease, and create ethical dilemmas.
- *Bioengineering of Organisms,* in which students review genetic modification techniques and consider how genetically modified organism can be used for the benefit of human health.

Criterion 8: Include the Use of Technology

The Futurelab+ curriculum was designed to be flexible for teachers who may have to alternate between in-person learning, virtual learning, or a hybrid environment. As such, the curriculum includes multiple opportunities for students to use a variety of programs that are open source and provides students with opportunities to manipulate data; run simulations; record videos and commercials; and, in Unit 4, design a career snapshot and hiring campaign with several components, including (1) an informational video, (2) career profile snapshot, and (3) an interactive job board.

Resources

Achieve & National Science Teachers Association. (2016). *NGSS lesson screener*. https://www.nextgenscience.org/screener

California Department of Education. (2007). *Career technical education framework for California public schools: Grades seven through twelve*. https://www.cde.ca.gov/ci/ct/sf/documents/cteframework.pdf

California Department of Education. (2017). *California career technical education model curriculum standards*. https://www.cde.ca.gov/ci/ct/sf/documents/healthmedical.pdf

Sacramento City Unified School District. (n.d.). *Protocols for culturally responsive learning and increased student engagement*. Retrieved October 11, 2021, from https://www.scusd.edu/sites/main/files/file-attachments/protocols_0.pdf?1445031253.

University of California. (n.d.). *Writing A–G Courses* [UC A–G Course Management Portal]. https://hs-articulation.ucop.edu/guide/update-your-a-g-list/writing-a-g-courses/

Appendix A. Example Science (D) Subject Course Description

The following sample course description was shared by the University of California to “give course authors a model for how to construct course overviews, unit overviews, and sample assignments” (University of California, “Sample course descriptions.”). The course description below can be found here.

Subject Area “D” Sample

Included in this sample is a single course overview, unit, and assignment; this is not a sample of a complete course, nor are all disciplines/courses represented in this sample. The purpose of these pieces is to give course authors a basic sample of how to construct strong course overviews, units, and assignments. Often, when a course is not approved by the UC High School Articulation Team, it is because the UC A-G Subject Area Specific Criteria is not explicitly written into a course submission. We encourage all course authors to consistently review the criteria specific to the subject/discipline under which they are submitting their courses.

Course Title: Biology / **Subject:** Laboratory Science / **Discipline:** Biology

Sample Course Overview:

In this course, students develop an in-depth understanding of the living world by studying structure, function and processes. Students recognize and understand the interactions of chemistry, physics, and earth sciences in the study of biology. Laboratory investigations incorporate procedures and develop the ability to analyze complex information. The main content areas of focus are cell biology, ecology, genetics, evolution, and physiology. Students will continue to develop their skills of reading, writing, discussion, technology, and analysis through lab reports, essays, and individual and group research projects. The ultimate course goal is to demonstrate scientific knowledge and skills as students work toward the school-wide goals of becoming self-directed learners who can identify a task and complete it, complex thinkers who can determine solutions to problems, and community contributors who can work collaboratively.

This course overview demonstrates the following strengths:

- Uses concise language which gives a global view of the course without sacrificing meaning,
- Includes a balance of skills and content (merely listing standards to be covered is not sufficient), and
- Previews how the course will integrate the following UC laboratory science “D” subject area requirements:
  - All courses approved in the laboratory science subject area should be designed with the explicit intention of developing and encouraging scientific habits of mind important for university-level studies and aligned with the eight practices of science and engineering identified by the National Research Council framework and detailed within the Next Generation Science Standards

Sample Unit: *Cells*

This unit builds upon key lessons introduced in the previous unit, the scientific process, data analysis, investigation and experimentation, by unifying the themes of biology. This unit covers chemical concepts, the differences between carbon-based molecules and proteins, the differences between aerobic and anaerobic respiration, and cell theories related to all living things and how they function. Students begin by understanding basic cellular functions and then move on to compare and contrast different cell types to develop mastery of the processes essential to homeostasis and the proper function of all living cells. Explanation of the properties of water will be applied to diffusion and osmosis across cell membranes. The concepts of chemical energy production and usage, photosynthesis and cellular respiration, will build a foundation for understanding the processes of cell growth and regulation. Enzymatic activity will be connected to the essential cellular processes as they apply to all living organisms. In total, this unit provides students with an inquiry-based approach to applying their knowledge of energy dynamics within cellular organelles while utilizing investigation and experimentation skills mastered in a previous unit.

Sample Unit Assignment: *Cells*

Supervised by course teacher, each student will explore how the sugar content of a banana changes as it ripens. Students will formulate a hypothesis as to the amount of sugar and starch content that are contained in samples of green, ripe and overripe bananas. After determining the sugar and starch concentrations of various samples, students will demonstrate their understanding of the process of fruit ripening by comparing their predictions to the data generated. Students will use the data collected from the lab to confirm whether their hypothesis was valid or disproved. Their conclusions regarding the relationship between sugar content, starch content, and the ripening process will be based on these comparisons. After predicting concentrations of sugar and starch in various banana samples, students will perform a test with Benedict's reagent to determine the presence of sugar and a test for the presence of starch using an iodine solution. Students will then use their predictions and collected quantitative data to demonstrate an understanding of the fruit ripening process. Students will be writing a two-to-three page lab report that includes that clearly states the hypothesis, experimental methods, collected data, analysis of the data, and conclusion of their findings.

While these single unit and assignment samples do not, nor are designed to, demonstrate all the UC subject area "d" course criteria, they clearly and concisely exhibit the components of the criteria listed below, are well-written, and ultimately answer the question: ***How do this single unit and assignment meet the UC criteria for a college-preparatory laboratory science course?***

This sample course unit and assignment demonstrate the following strengths & course criteria:

- provides rigorous, in-depth treatments of the conceptual foundations of the scientific subject studied based on the appropriate underlying biological, chemical and physical principles
- affords students opportunities to participate in all phases of the scientific process, including formulation of well-posed scientific questions and hypotheses, design of experiments and/or data collection strategies, analysis of data, and drawing of conclusions; they will also require students to discuss scientific ideas with other students, differentiate observations from interpretations, engage in critical thinking and write clearly and coherently on scientific topics
- employs quantitative reasoning and methods wherever appropriate
- includes a teacher-supervised, hands-on laboratory activities that are directly related to, and support, the other class work, and that involve inquiry, observation, analysis and write-up

Appendix B. Sample Unit Overview, Assignment Overview, and Lab Activity

Example Unit Overview: *Behind the Scenes of Scientific Breakthroughs*

In *Behind the Scenes of Scientific Breakthroughs*, students investigate the hallmarks of cellular aging. They also examine how genetic sequencing and genetic modification can be used to increase longevity, affect protein function, alter traits, treat diseases, and even create ethical dilemmas. Students work in teams, and they play the role of either a project manager, biotechnology researcher, biotech recruiter, or design specialist. As a team, they choose one of four scientific breakthroughs as a focus for their research. Throughout the unit, they develop an understanding of the breakthrough, determine who they need to hire to move their innovation through the development process, and create an interactive hiring board aimed at filling those roles.

Example Unit Assignment: *Biotech Careers in Longevity Project*

Supervised by the course teacher, students complete learning activities to develop content knowledge and skills needed for the unit's final project, which is to investigate a scientific breakthrough in longevity. Students must determine the jobs needed to complete the development and implementation of their breakthrough and create a hiring campaign that includes career profiles, an informational video on their breakthrough, and an interactive hiring board (Biotech Careers in Longevity Project Design Journal, p. 3). First, through research, students identify a longevity innovation and the problem it addresses. Then students research cellular aging, genetic sequencing, The Human Genome Project, synthetic DNA, bioengineering, cloning and stem cell research, ethics in biotechnology, and senolytics. Using the information they gathered, students create a longevity scientific breakthrough introductory video that defines the problem and summarizes the breakthrough. Finally, students identify the human resources needed to complete the development cycle of their innovation and create a hiring campaign that includes a career snapshot and an interactive job board (Biotech Careers in Longevity Project Design Journal, p. 4).

Lab Activity: *Longevity Markers: How are you so old?*

In this teacher-supervised lab, student groups model the steps in a Genome-Wide Association Study. First, students extract DNA from their own cheek cells and run a gel electrophoresis on their DNA. Then, using a genetic database, they analyze mock genotype data to identify links between genetic SNPs and longevity.

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