NGSS Innovations and Design Principles Feedback: Summative Review 4, Unit 4, Lesson 1

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 (CTE) Model Curriculum Standards for Biotechnology, meet at least 1 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 1 week to complete (9–10 weeks for the full unit). In total, the biotechnology curriculum has 72 lessons and eight labs that span 2 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.

As an organizational partner, the American Institutes for Research (AIR) provided external feedback about alignment of the curriculum 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 regarding each unit of the final curriculum's alignment to each set of standards in three series of reports: CTE, UC science (D) subject requirement, and NGSS. The eight reports in the NGSS series provide feedback about aspects of NGSS in a sample of the curriculum (one lesson from each unit). Developers selected Lesson 1 (Cellular Aging) from Unit 4 (Behind the Scenes of Scientific Breakthroughs) for this report. **This review was completed on materials received March 24, 2022 and has not been updated to reflect any revisions made to materials since then.**

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 4, Lesson 1, **meet three lesson screener criteria** and **approach the remaining three lesson screener criteria**. AIR created the *approaching* rating to indicate where a modification to materials would increase the rating to *adequate*. NGSS criteria, ratings, and recommendations are summarized in Exhibit 1.

Exhibit 1. NGSS Criteria, Ratings, and Recommendations

Criterion		Rating
NGSS Shifts	**A. Explaining Phenomena or Designing Solutions**	Adequate
	B. Three Dimensions	▪ DCI: Adequate ▪ SEP: Adequate ▪ CCC: Adequate Overall rating: Adequate
	C. Integrating the Three Dimensions for Instruction and Assessment	Adequate
Features of Quality Design	**D. Relevance and Authenticity**	Approaching
	E. Student Ideas	Approaching
	F. Building on Students' Prior Knowledge	Approaching

Note. DCI = disciplinary core ideas; SEP = science and engineering practices; CCC = cross-cutting concepts.

- **Criterion A: Explaining Phenomena or Designing Solutions** *(Adequate)*. All activities in the lesson help students increase their understanding of how cells change as we age and how cellular aging impacts human health.
- **Criterion B: Three Dimensions** *(Adequate)*. There is sufficient evidence that the current materials give students opportunities to build their understanding of science and engineering practices (SEPs), disciplinary core ideas (DCIs) and cross-cutting concepts (CCCs).
- **Criterion C: Integrating the Three Dimensions for Instruction and Assessment** *(Adequate)*. There is sufficient evidence that materials give students opportunities to build their understanding of SEPs, DCIs, and CCCs.
- **Criterion D: Relevance and Authenticity** *(Approaching)*. The reviewers found adequate evidence that the materials engage students and teachers in authentic scenarios that reflect the real world. Materials include many culturally responsive instructional strategies and are linked to information for teachers on how to incorporate them. The language in the teacher materials, specifically "maintaining a good attention span" (Teacher Section, p. 8) and "being a fast learner" (Teacher Section, p.11), emphasize soft skills. Students with learning disabilities may struggle with these skills and be discouraged from pursuing a biomedical research or bioinformatics career.
- **Criterion E: Student Ideas** *(Approaching)*. There is insufficient evidence that the materials provide students with opportunities to share their ideas and provide feedback about their peers' ideas—both essential science skills. Including opportunities for students to refine their work, present initial understandings, or provide feedback to their peers would increase alignment to this criterion.
- **Criterion F: Building on Students' Prior Knowledge** *(Approaching)*. There is insufficient evidence that the materials identify and build on students' prior learning in all three dimensions. The materials make little to no connection between prior knowledge in the SEPs and CCCs students are expected to have and learn in the unit. However, the materials clarify students' expected level of proficiency with the DCIs and CTE content learning in the unit. **Explicit connections to students' prior learning concerning SEPs and CCCs could improve alignment to this criterion.**

AIR's review also included feedback regarding alignment of the lesson to three of the eight Futurelab+ guiding principles: equity, adaptability, and industry driven. Unit 4, Lesson 1, met all three of these guiding principles:

- ***Equity***. Materials include diverse representation throughout activities and visual media and incorporate several protocols for culturally responsive teaching and increased student engagement. The Industry and Career Connection on page 11 of the Teacher Section includes a note that technical skills for this career include being a "fast learner" and "maintaining a good attention span," which could discourage some students from considering a career as a bioinformatician. As noted previously, the language in the teacher materials, specifically "maintaining a good attention span" (Teacher Section, p. 8) and "being a fast learner" (Teacher Section, p.11), emphasize soft skills that students with learning disabilities may struggle with, which, in turn, could discourage them from pursuing a biomedical research or bioinformatics career.
- ***Adaptability***. Materials appear to be adaptable and allow teachers to move between virtual, in-person, or hybrid settings, using different synchronous and asynchronous teaching methods.
- ***Industry driven***. Students take the roles of *biomedical researcher* and *bioinformatician* to begin researching factors that contribute to cellular aging and, ultimately, organism aging.

Methodology

Released in 2013, the Next Generation Science Standards (NGSS) were developed by a consortium of states, teacher associations, and nonprofit organizations. The purposes of NGSS are to (1) combat ignorance of science, (2) create common teaching standards, and (3) develop greater interest in science among students so that more students choose to major in science in technology. The focus on the purposes requires changes in how science is taught and the materials used to teach science. These changes, or innovations, shift the focus of science instruction from an abstract recall of facts to students demonstrating proficiency by engaging in scientific practices.

Three dimensions are integrated into the NGSS and throughout NGSS-aligned materials: science and engineering practices (SEPs), cross-cutting concepts (CCCs), and disciplinary core ideas (DCIs).

Methods

The 2-year biotechnology curriculum consists of four core units each year. Each core unit has nine lessons and a lab. As is typical with NGSS-aligned lessons, a lesson consists of more than one class period of instruction 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 and covers 2 instructional years.

The American Institutes for Research (AIR) was asked to provide feedback and evidence of incorporation of some of the three-dimensional learning innovations common to the NGSS on a sample of the biotechnology curriculum. **Because the curriculum was designed to align primarily to CTE standards, it was not expected that the curriculum would meet all NGSS criteria**.

Additionally, there are significant similarities between the innovations measured by the NGSS Lesson Screener and the University of California (UC) science (D) subject requirement, as shown in Exhibit 2. For this reason, AIR selected to use the NGSS Lesson Screener for supporting evidence of three-dimensional learning.

Exhibit 2. Similarities Between UC Science Requirements and Measured Innovations

There are significant similarities 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 SEPs (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.

NGSS Lesson Screener

The NGSS Lesson Screener, developed by Achieve in collaboration with the National Science Teaching Association, is a framework for collecting evidence on (1) whether a lesson being developed or revised is on the right track for incorporating NGSS innovations, (2) if a lesson warrants further review using the EQuIP Rubric, and (3) to what extent a group of reviewers have a common understanding of the NGSS or of designing lessons for the NGSS. Because these materials were designed primarily to align to CTE standards, with aspects of NGSS and three-dimensional learning incorporated, using the Lesson Screener was more appropriate than using the EQuIP Rubric.

The NGSS Lesson Screener includes six criteria (labeled A–F). The first three Lesson Screener criteria (A–C) consider evidence of three NGSS shifts: (A) Explaining Phenomena or Designing Solutions, (B) Three Dimensions (of learning), and (C) Integrating the Three Dimensions for Instruction and Assessment. The last three NGSS criteria (D–F) consider features of quality design: (D) Relevance and Authenticity, (E) Student Ideas, and (F) Building on Students' Prior Knowledge.

Each screener criterion lists several indicators that help determine the extent to which a lesson incorporates an innovation. In other words, these indicators, or descriptions, denote whether the lesson materials meet a criterion. **A rating of *adequate* or higher means that the lesson meets the criterion**.

Possible criterion ratings on the NGSS Lesson Screener include the following:

- None (no evidence to meet the criterion)
- Inadequate (limited evidence to meet the criterion or direct evidence that the materials are not aligned)
- Adequate (enough evidence to meet the criterion)
- Extensive (more than enough evidence to meet the criterion)

For this curriculum review, AIR added an *approaching* rating to the NGSS criterion ratings. This new rating, created by AIR, indicates where a slight modification to materials would increase the rating to *adequate*.

Sampling

To complete the series of NGSS Lesson Screener reviews, AIR sampled one lesson in each of the eight core units for a total of eight NGSS alignment and evidence reviews. **AIR randomly selected four of the lessons; the other four lessons were re-reviews of materials AIR reviewed during the formative review process**. AIR re-reviewed Lesson 1 (Cellular Aging) from Unit 4 (Behind the Scenes of Scientific Breakthroughs) for this report.

Two AIR staff independently and then collaboratively reviewed Unit 4, Lesson 1, to provide impartial evidence of where in the lesson and to what extent NGSS innovations are incorporated. After each AIR reviewer independently completed the review and provided a rationale for the ratings on each indicator, the team met to arrive at a final rating for each criterion (see Exhibit 3).

Exhibit 3. Lesson Review Process

Following the Lesson Screener standard review protocol, the AIR review team

- individually reviewed the lesson to record criterion-based evidence,
- individually made suggestions for improvement,
- collaboratively discussed findings to make a final rating determination, and
- summarized findings into a report.

Feedback and Evidence: Unit 4, Lesson 1

AIR found evidence that Unit 4, Lesson 1, materials meet three of the six NGSS criteria identified by the Lesson Screener and are approaching the remaining three criteria. All six criteria and evidence supporting AIR's ratings are discussed in detail in this section (see summary in Exhibit 1).

NGSS Ratings and Evidence

Rating for Criterion A: Explaining Phenomena or Designing Solutions: *Adequate*

The reviewers found adequate evidence within the lesson that learning is driven by students making sense of phenomena. The goal of each of the activities reviewed in Lesson 1 is to prepare students for their final project by increasing student understanding of whether science can increase the longevity of a cell. AIR did not review the design journal referenced in the materials for this report other than to confirm the project summary and design.

The lesson materials achieve the *adequate* rating for this criterion because they include examples of opportunities and support for students making sense of the phenomena, as evidenced by the following activities:

- **Day 1 Activities**: The lesson begins with an opening activity in which students assume the role of scientists researching a scientific breakthrough and discovering different roles and tasks they will need to complete. Students then share their initial thoughts about whether a cell can live forever. Finally, students review the hallmarks of cellular aging, compare models of a young cell and an old cell to identify similarities and differences, and then create a presentation for sharing that information (Teacher Section, pp. 5–8).
- **Day 3 Activities**: Students develop several models to outline regions of DNA and their roles in cellular aging. Students also draw conclusions about the impact of lifestyle factors on telomeres and present their findings to their peers (Teacher Section, pp. 8–10).

Rating for Criterion B: Three Dimensions: *Adequate*

The reviewers found adequate evidence within the lesson that students are provided opportunities to build their understanding of grade-appropriate elements in **<u>all three dimensions</u>**. Throughout these activities, students engage frequently in **Obtaining, Evaluating, and Communicating Information** and **Developing and Using Models** to develop an understanding of the hallmarks of cellular aging. Additionally, students explicitly use the CCCs of both **Patterns** and **Structure and Function** to explain and describe their thinking.

The following bulleted evidence supports the *adequate* rating for this criterion because the lesson materials include examples of opportunities and support for students explicitly developing their understanding of elements of SEPs, DCIs, and CCCs:

SEPs, including:

- **Obtaining, Evaluating, and Communicating Information**: Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source (Student Section, pp. 12–18).
- **Developing and Using Models**: Develop and/or use models to describe and/or predict phenomena (Student Section, pp. 1–2).

DCIs, including:

- **LS1.A**: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain instructions for coding the formation of proteins (Student Section, pp. 4–6).

CCCs, including:

- **Patterns**: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena (Teaching Section, pp. 8, 10, 17).
- **Structure and Function**: Investigating or designing new systems of structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem (Teacher Section, p. 8; Student Section, p. 32).

Rating for Criterion C: Integrating the Three Dimensions for Instruction and Assessment: ***Adequate***

The reviewers found adequate evidence within the lesson that students are provided opportunities to build their understanding of grade-appropriate elements in **all three dimensions**. Throughout these activities, students frequently engage in **Obtaining, Evaluating, and Communicating Information** and **Developing and Using Models** as they develop an understanding of the hallmarks of cellular aging. Additionally, students explicitly use the CCCs of both **Patterns** and **Structure and Function** to explain and describe their thinking about how older cells differ from younger cells. The following bulleted evidence supports the *adequate* rating for this criterion because the lesson materials include examples of opportunities and support for students to explicitly demonstrate their understanding of elements of SEPs, DCIs, and CCCs:

SEPs, including:

- **Obtaining, Evaluating, and Communicating Information**: Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source (Student Section, pp. 12–18).
- **Developing and Using Models**: Develop and/or use models to describe and/or predict phenomena (Student Section, pp. 1–2).

DCIs, including:

- **LS1.A**: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain instructions for coding the formation of proteins (Student Section, pp. 4–6).

CCCs, including:

- **Patterns**: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena (Teaching Section, pp. 8, 10, 17).
- **Structure and Function**: Investigating or designing new systems of structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem (Teacher Section, p. 8; Student Section, p. 32).

Rating for Criterion D: Relevance and Authenticity: ***Approaching***

The reviewers found insufficient evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. Although some activities allow students to make real-world connections, such as the Diseases and Lifestyle Factors presentation, many activities are content driven or very closely directed by the teacher. Alignment to this criterion could be improved if students were provided opportunities to refine their poster or presentation or offer feedback to their peers or if students were provided time to consider how cellular aging connects to their own lives.

The following bulleted evidence supports the *approaching* rating for this criterion:

- **Day 3 Activities**: Students develop several models to outline regions of DNA and their roles in cell aging. Students also draw conclusions about the impact of lifestyle factors on telomeres and present their findings to their peers (Teacher Section, pp. 8–10).

Rating for Criterion E: Student Ideas: *Approaching*

The reviewers found insufficient evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. Although some activities allow students to make real-world connections, such as the Diseases and Lifestyle Factors presentation, many activities are content driven or very closely directed by the teacher. Alignment to this criterion could be increased if students were provided opportunities to ask questions about cellular aging, refine their poster or presentation, or offer feedback to their peers or if students were provided a choice in how to share and communicate their research.

The following bulleted evidence supports the *approaching* rating for this criterion:

- **Day 1 Activities**: The lesson begins with an opening activity in which students assume the role of scientists researching a scientific breakthrough and discovering different roles and tasks they will need to complete. Students then share their initial thoughts about whether a cell can live forever. Finally, students review the hallmarks of cellular aging, compare models of a young cell and an old cell to identify similarities and differences, and then create a presentation for sharing that information (Teacher Section, pp. 5–8).
- **Day 3 Activities**: Students develop several models to outline regions of DNA and their roles in cellular aging. Students also draw conclusions about the impact of lifestyle factors on telomeres and present their findings to their peers (Teacher Section, pp. 8–10).

Rating for Criterion F: Building on Students' Prior Knowledge: *Approaching*

The reviewers found inadequate evidence that the materials identify and build on students' prior learning in all three dimensions because the materials make little to no connection between expected prior learning in the SEPs and CCCs and learning in the unit. However, the materials clarify students' expected level of proficiency with the DCIs and CTE content learning in the unit. Alignment of materials to this criterion could be increased if the materials would provide explicit connections to students' prior learning concerning SEPs and CCCs, for example, asking students what they already know about models and then introducing new ways in which models can be used or holding a discussion about structure and function or patterns in data before diving into the learning activity.

Futurelab+ Design Principles

Although several Futurelab+ design principles (Exhibit 4) overlap with the Lesson Screener criteria, especially concerning Principle 1 (Equity) and Principle 6 (Education Standards Aligned), AIR was asked to look for evidence of the design principles independent of NGSS. Within this section, AIR provides feedback regarding the principles of Equity, Adaptability, and Industry Driven.

Feedback about the principle of Education Standards Aligned can be surmised from the CTE alignment matrix and summary evidence reports provided for each unit.

Feedback about the principle of California Focus can be surmised from the California Subject Matter D report prepared for each unit. No formal evaluation tool was created or used to provide this feedback.

Feedback is not provided about all principles because the focus of other principles relates to the design of the materials.

Exhibit 4. Futurelab+ Principles

1. **Equity** | **Prioritize** meeting the needs of the most **underserved students** using socially responsible language.
2. **Adaptability** | Empower and equip teachers and students to **seamlessly move between virtual and in-person learning** environments.
3. **Industry Driven** | Reflect **in-demand biotech skills** and **career-laddering opportunities.**
4. **Teacher Voice** | Informed by **teacher input** and must be **teacher-demand driven.**
5. **Teaching Breadth and Inclusivity** | Build to engage a **broad set of teachers.**
6. **Education Standards Aligned** | Demonstrate **relevance** and **validity** with educators.
7. **Open Source** | Opt for **open frameworks** over proprietary approaches.
8. **California Focus** | Prioritize **California state standards and educational contexts** as a foundation for future scaling efforts nationwide.

Equity

Unit 4, Lesson 1, includes diverse representations of gender, ethnicities, and age groups throughout activities and visual media. This lesson incorporates several Protocols for Culturally Responsive Learning and Increased Student Engagement adapted from the work of Amy Coventry at the Center for Culturally Responsive Teaching and Learning. The Industry and Career Connection on page 11 of the Teacher Section includes a note that one of the technical skills for this career is being a "fast learner." Additionally, a note on page 8 of the Teacher Section notes a major soft skill for biomedical researchers is the ability to "maintain a good attention span" (Teacher Section, p. 8). Although these notes are included for the teacher, this wording could discourage some students with disabilities from considering a career in either of these fields.

Adaptability

Unit 4, Lesson 1, materials appear adaptable and allow teachers to move between virtual, in-person, or hybrid settings using different synchronous and asynchronous teaching methods. Futurelab+ may consider giving suggestions to teachers during professional learning activities or in notations on the website for where and how lessons could be moved between platforms.

Industry Driven

In Unit 4, Lesson 1, students assume the roles of both biomedical researchers and bioinformaticians as a way to understand these careers in biotechnology.

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.

Appendix A. Lesson Screener Criteria

	Criterion	Description
NGSS Shifts	**A. Explaining Phenomena or Designing Solutions**	The lesson focuses on supporting students to make sense of a phenomenon or design solutions to a problem.
	B. Three Dimensions	The lesson helps students develop and use multiple grade-appropriate elements of the SEPs, DCIs, and CCCs, which are deliberately selected to aid student sensemaking of phenomena or designing of solutions.
	C. Integrating the Three Dimensions for Instruction and Assessment	The lesson requires student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the lesson elicits student artifacts that show direct, observable evidence of three-dimensional learning.
Features of Quality Design	**D. Relevance and Authenticity**	The lesson motivates student sensemaking or problem solving by taking advantage of student questions and prior experiences in the context of the students' homes, neighborhoods, and communities, as appropriate.
	E. Student Ideas	The lesson provides opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback.
	F. Building on Students' Prior Knowledge	The lesson identifies and builds on students' prior learning in all three dimensions in a way that is explicit to both the teacher and the students.

Note. DCI = disciplinary core ideas; SEP = science and engineering practices; CCC = cross-cutting concepts.

1400 Crystal Drive, 10th Floor
Arlington, VA 22202-3289
202.403.5000

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