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A GENENTECH SCIENCE EDUCATION PROGRAM

NGSS Innovations and Design Principles Feedback: Summative Review Unit 5, Yogurt Fermentation Lab

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 the lab activity, Yogurt Fermentation, from Unit 5 (Solution Seeking Microbes) for this report. **This review was completed on materials received May 31, 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 5 Laboratory Investigation: Yogurt Fermentation **meet four and approach two of the six 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**	Adequate
	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).* Students investigate how microbes can be used for both human health and food production through fermenting their own yogurt.
- **Criterion B: Three Dimensions** *(Adequate*). Activities focus primarily on practices and core ideas, but do not address cross-cutting concepts, although natural connections exist to do so.
- **Criterion C: Integrating the Three Dimensions for Instruction and Assessment** *(Adequate)*. Activities focus on gathering evidence of student understanding of practices and a core idea, but do not address cross-cutting concepts, although natural connections exist to do so.
- **Criterion D: Relevance and Authenticity** *(Adequate)*. The reviewers found adequate evidence that materials are relevant and authentic for students.
- **Criterion E: Student Ideas** *(Approaching)*. The materials include several opportunities and activities to allow peer interaction and student reasoning. However, the extent to which students can reflect on and change their thinking is not clear.
- **Criterion F: Building on Students' Prior Knowledge** *(Approaching)*. Materials in their current form may build on students' prior knowledge in some content, but connections need to be strengthened to meet the 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. The materials for the Unit 5 lab investigation Yogurt Fermentation met all three of these guiding principles:

- ***Equity*.** Materials do not appear to include any barriers for students and include diverse representation across materials. Materials include scaffolded supports for teachers to help students develop cultural competency and explore unconscious biases.
- ***Adaptability*.** Materials appear to be adaptable to virtual, in-person, or hybrid settings with virtual learning options for the lab included in the Teacher Section; however, teachers may need to make additional considerations about materials access for students at home.
- ***Industry Driven*.** The content for the Unit 5 lab investigation Yogurt Fermentation appears to be industry driven. The lab investigation includes role profiles for both microbiologists and food scientists, as well as a career profile for a microbiologist as a student extension activity.

Methodology

Released in 2013, the 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 or `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: SEPs, CCCs, and 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.

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.**

In addition, 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 indicates where a 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 randomly selected the lab investigation, Yogurt Fermentation, from Unit 5 (Solution Seeking Microbes).

Two AIR staff independently and then collaboratively reviewed the Unit 5 lab investigation Yogurt Fermentation 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 5 Laboratory Investigation: Yogurt Fermentation

AIR found evidence that Unit 5 Laboratory Investigation: Yogurt Fermentation materials meet four and approach two of the six 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***

Students begin the lesson by identifying various foods that are prepared through bacterial fermentation. Next, they observe two unknown samples and identify the sample containing bacteria. The following day, students analyze data from published studies to learn how different variables affect yogurt production and choose one variable to adjust in their own experiment.

The following bulleted evidence supports the *adequate* rating for this criterion because the lesson materials include examples of opportunities and support for students making sense of the phenomena:

- **Day 1 activities:** Students observe and discuss foods from different cultures to determine what they have in common—beneficial bacterial fermentation (Teacher Section, p. 5).
- **Day 2 activities**: Students analyze evidence about the effect of different variables on yogurt fermentation. Then they select a variable to adjust in their experiment to observe the effect it has on their sample (Teacher Section, pp. 8–9).

Rating for Criterion B: Three Dimensions: ***Adequate***

The reviewers found that the materials provide opportunities to build understanding in **all three dimensions**. Specifically, activities focus on student understanding of practices and core ideas. As well, students investigate the cross-cutting concept of cause and effect by selecting a variable to adjust and then determining how that variable affected the bacterial fermentation of their sample.

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 develop their understanding of the following:

SEPs, including:

- **Planning and Carrying Out Investigations.** Students make predictions about what will happen when they change a variable in their yogurt fermentation laboratory investigation (Student Section, p. 35).
- **Engaging in Argument From Evidence.** Students make a claim about how the variable they changed affected the characteristics of their kefir sample (Student Section, p. 39).

DCIs, including:

- **LS1-C.** As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products (Teacher Section, p. 15).

CCCs, including:

- **Cause and Effect.** Students review data from published studies that describe how different variables affect yogurt fermentation. Then they choose one variable to change in their own yogurt fermentation experiment (Teacher Section, pp. 8–9).

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

The reviewers found that the materials provide opportunities to build and assess understanding of grade-appropriate elements in **all three dimensions**. 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 the following:

SEPs, including:

- **Engaging in Argument From Evidence.** Students make a claim about how their independent variable affected the characteristics of their kefir yogurt (Student Section, p. 39).

DCIs, including:

- **LS1-C.** Students observe two different liquids to look for evidence of bacteria so they can choose an appropriate starter culture for their yogurt fermentation experiment (Student Section, p. 30).

CCCs, including:

- **Crosscutting Concepts.** Students make a prediction about how changing a variable in their experimental group will affect their kefir yogurt, and what would happen if the control variables are not kept constant (Student Section, p. 32).

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

The reviewers found adequate evidence that materials are relevant and authentic for students. The following bulleted evidence supports the *adequate* rating for this criterion:

- **Day 1 Whole Group.** Students share what they know about the fermented foods they are observing. The teacher section includes a note to ensure students who may not typically respond to prompts are given an opportunity to share what they know about these foods (Teacher Section, p. 5).

Rating for Criterion E: Student Ideas: ***Approaching***

The reviewers found evidence that the materials provide students with opportunities to review other student work, though students would benefit if they could solicit student feedback and have an opportunity to adjust their thinking.

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

- **Day 5 Whole Group.** Students conduct a "gallery walk" to review other students' data on how variables affected their kefir yogurt (Teacher Section, p. 5).

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 CCCs and learning in the unit. The materials in their current form suggest that students are applying learning from previous lessons in this unit to plan investigations and to identify whether living organisms are present in an unknown liquid. However, the progression that builds on students' prior knowledge is not explicit, and there are limited opportunities for students to question or share prior knowledge.

Futurelab+ Design Principles

Although several Futurelab+ design principles (Exhibit 4) overlap with the Lesson Screener criteria, especially concerning Principles 1 (Equity) and 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

The materials include diverse representation and do not appear to include any barriers for students. The materials include scaffolded supports for teachers to help students develop cultural competency and explore unconscious biases. Students are provided an opportunity to share what they know about various cultural foods that are prepared through fermentation, such as kimchi, yogurt, sourdough, and miso.

Adaptability

The materials appear to be adaptable to virtual, in-person, or hybrid settings with virtual learning options for the lab included in the Teacher Section (pg. 21). However, this assumes students have materials at home to make yogurt including milk and kefir which may not be readily available to students in the home.

Industry Driven

The content for the Unit 5 lab investigation Yogurt Fermentation appears to be industry driven. The materials include a role profile that describes what a microbiologist does, and students have the opportunity to respond to a prompt in their toolkit about the types of people who do science.

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*. https://www.scusd.edu/sites/main/files/file-attachments/protocols_0.pdf?1445031253

Appendix. 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.

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