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Genetically Modified Microbes to Accelerate Composting Food Waste

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ABE Master Teacher Fellowship Program

AMGEN Biotech Experience

Scientific Discovery for the Classroom

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The projects designed by the 2024–25 ABE Master Teacher Fellows are a compilation of curricula and materials that are aligned with the Amgen Biotech Experience (ABE) and further support teachers and students in their biotechnology education. These projects were created over the course of a 1-year Fellowship in an area of each Fellow's own interest. Each is unique and can be adapted to fit the needs of your individual classroom. Objectives and goals are provided, along with expected outcomes. Projects can be used in conjunction with your current ABE curriculum or as an extension.

As a condition of the Fellowship, these classroom resources may be downloaded and used by other teachers for free. The projects are generally not edited or revised by the ABE Program Office for content, clarity, or language except to ensure safety protocols have been clearly included where appropriate.

We are grateful to the ABE Master Teacher Fellows for sharing their work with the ABE community. If you have questions about any of the project components, please reach out to us at ABEInfo@edc.org, and we will be happy to connect you with the author and provide any assistance needed.

AMGEN Biotech Experience

Scientific Discovery for the Classroom

Greater Los Angeles

Genetically Modified Microbes to Accelerate Composting Food Waste

TIME FRAME: 4–5 weeks (2–6 months if starting a compost bin)

SUGGESTED AGE RANGE: Grades 6–12

SUGGESTED COURSE OR CONTENT AREA: Environmental Science

CONNECTION DESCRIPTIONS:
Teachers will select at least one of the following lenses to act as the overlay for the unit.

- Precision and personalized medicine
- Molecular modeling
- Evolution and population genetics
- Career pathways for bioscience careers, neuroscience, and others
- Integrating inquiry
- Data analysis/data literacy
- Project or problem-based learning
- Professional skills in STEM/profiles in STEM
- Eye on the news- current real-world applications for ABE concepts, content, and technologies

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PROGRAM SITE: ABE Greater Los Angeles | California State University Channel Islands

Overview:

I have designed this lesson to help environmental science students understand the importance of sustainability and taking action to create a better world. Not only will this Capstone Project provide knowledge-based and skill/lab-based learning, but it will also provide students with affective outcomes. It will empower students to make more environmentally responsible choices around waste reduction and climate action. It will foster a sense of responsibility and agency in building a more sustainable future for all. In addition, California students could apply and earn a State Seal of Civic Engagement on their high school diploma.

Environmental science students will have covered sustainable food waste management and composting in Section 8.10, "Waste Reduction Methods" and genetically modified organisms (GMO) and soil fertility in Section 5.3, "Green Revolution." With the concepts they learned, students will apply their knowledge and participate in a food waste and composting program at Adolfo Camarillo High School after Advanced Placement (AP) testing in May. While setting up composting piles, students will research current genetically modified (GM) and naturally occurring composting microbes. Although GM composting microbes are not available to purchase at this time, students can research the many ways Biotechnology can enhance composting. The ABE Focus on Bacteria Series will be implemented for students to gain real-world hands-on experiences with making GM microbes using similar processes to what is done for the waste management industry. There are many extensions that can be added depending on time (campus food waste collection, campus wide education, public service announcements, inquiry experimentations/investigations, State Seal of Civic Engagement, etc.)

Learning Goals:

- Understanding waste reduction methods (sustainable food waste management and composting)
- Understanding the Green Revolution (GMO and soil fertility)
- Understanding the role of GM and naturally occurring composting microbes
- Exploring the application of biotechnology to make GM composting microbes
- Understanding the fundamentals of biotechnology
- Developing laboratory skills while genetically modifying bacteria
- Conducting controlled experiments and collecting data

Assessed Outcome:

- Quizzes
- Post-test
- Lab report to evaluate students' ability to follow procedures and interpret results
- Direct observation by teacher
- Performance assessments
- Classroom presentations of capstone project
- Earning a State Seal of Civic Engagement

Key Vocabulary:

a. Composting of Food Waste

- Compost – Decayed organic material used as a plant fertilizer.
- Decomposition – The process by which organic substances are broken down into simpler organic matter.
- Organic Waste – Waste material from plants or animals that is biodegradable.
- Aerobic – Requires oxygen; aerobic composting involves oxygen-loving microbes.
- Anaerobic – Occurs without oxygen; slower process that can produce methane.
- Microorganisms – Tiny organisms like bacteria and fungi that break down waste.
- Green Material – Nitrogen-rich compostable items (e.g., food scraps, grass clippings).
- Brown Material – Carbon-rich compostable items (e.g., dried leaves, cardboard).
- Leachate – Liquid that drains from compost or landfill, possibly containing nutrients or pollutants.
- Humus – The dark, nutrient-rich material that remains after decomposition is complete.
- Food Scraps – Leftover or discarded pieces of food.
- Upcycling – Reusing food waste in creative ways.
- Waste Diversion – Preventing waste from going to landfills.

b. Molecular Biology

- DNA (Deoxyribonucleic Acid) – The molecule that carries genetic information.
- Gene – A segment of DNA that codes for a protein.
- Plasmid – A small, circular piece of DNA found in bacteria, often used in genetic engineering.
- Transformation – The process of introducing foreign DNA (like a plasmid) into a bacterial cell.
- Recombinant DNA – DNA that has been artificially formed by combining DNA from different organisms.
- Gene Expression – The process by which a gene's instructions are used to make a protein.

c. Biotechnology

- Biotechnology – The use of living organisms or systems to develop useful products.
- Genetic Engineering – The direct manipulation of an organism's DNA.
- GMO (Genetically Modified Organism) – An organism whose genetic material has been altered.
- Recombinant DNA – DNA that has been formed artificially by combining genes from different organisms.
- Plasmid – A small DNA molecule within a cell that can be used to transfer genes.
- Expression Vector – A plasmid designed to ensure the expression of an inserted gene.
- Bioremediation – Use of microbes (including GM bacteria) to clean up pollution or waste.
- Bioconversion – The transformation of organic materials (e.g., food waste) into useful products using biological processes.

d. Laboratory Tools and Techniques
   - Micropipette
   - Centrifuge
   - Water bath
   - Sterile technique – Methods used to prevent contamination in experiments.
   - LB (Luria Broth) – A nutrient-rich media used for growing bacteria.
   - Arabinose
   - Ampicillin – An antibiotic used to select for bacteria that have antibiotic resistance genes.
   - Antibiotic resistance – The ability of bacteria to survive and grow in the presence of an antibiotic.
   - Agar plate – A petri dish filled with a gelatinous medium used to culture bacteria.
   - Colony – A visible mass of bacterial cells that originated from a single parent cell.
   - Incubation – Keeping cultures at a specific temperature to promote growth.

Materials and LabXchange Pathway(s):

a. Materials
   - Composting bins
   - Green (plant-based food) and brown (leaves) waste
   - Shovel
   - Water
   - ABE Focus on Bacteria Sequence materials and consumables

b. LabXchange Pathway(s)
   * = possible (not used with students yet)

   - Exploring How Humans Harness the Power of Prokaryotes*
   - Reducing Food Waste: Save Food to Save the Planet*
   - Can Soil Microbes Improve Agricultural Sustainability?*
   - Microbes: Agriculture's Microscopic Helpers*
   - Introduction to the Micropipette
   - Micropipetting Solutions
   - Loading a Micropipette
   - Using a Micropipette
   - Micropipetting Best Practice
   - Using a Micropipette
   - Loading an Agarose Gel
   - Separating DNA With Gel Electrophoresis
   - Gel Electrophoresis
   - Gel Electrophoresis Equipment and Applications
   - Transformation of DNA
   - Transforming Bacteria
   - Plating Transformed Bacteria
   - Bacterial Transformation

Teacher Preparation:

Compost takes 2–6 months to produce starting with food scraps. After setting up the compost bins and layering the organic material, plan that the compost bins are maintained on a weekly basis: mixing, monitoring moisture, layering. To speed up the decomposition process: chop or shred food waste and add composting microbes. Start at the beginning of the year so that there is enough time for all the Learning Goals to be covered. Teachers will also need to be trained with ABE for the Focus on Bacteria Sequence.

Lab Safety Considerations

a. Composting
   - Wear gloves when handling compost or food waste to avoid direct contact with bacteria, mold, or sharp objects.
   - Inspect food waste before composting to ensure no plastic, glass, or metal is included.
   - Keep food and drinks out of the lab or compost area.
   - Wear safety goggles if there's a chance of splashing during mixing or watering.
   - Do not compost meat, dairy, or oily foods in classroom bins (they can produce pathogens or attract pests).
   - Always wash hands after composting.

b. ABE Focus on Bacteria Sequence
   - See ABE Teachers manual safety precautions

Sequence of Activities

Activity Description	*Time*	*Materials*
1. Introduce Capstone Project template and State Seal of Civic Engagement	50 min (with homework)	2 Slides Presentations
2. Food waste audit	50 min (with homework)	safety glasses, gloves, Audit directions and data tables
3. Composting lesson and starting the process (with weekly turning and observations)	50 min	video, bins, green waste, brown waste, water
4. Composting Microbes lesson a) Microbes: Agriculture's microscopic helpers b) Researching GM soil microbe applications c) Class Discussion on GM microbes	100 min (with homework)	LabXchange Text on soil microbes, Chromebook
5. Recombinant DNA Technology lesson a) Bacteria & virus lesson with chart	1 week	Lecture slides, activities, lecture figures, review

Activity Description	*Time*	*Materials*
b) Recombinant DNA technology lesson c) Restriction enzyme practice handout and worksheet d) Recombinant DNA lab e) Restriction Enzyme Quiz f) Genetic engineering review worksheet g) ABE test		worksheet, hardcopy quiz, Google form, ABE test
6. ABE: Focus on Bacteria lab series	2 weeks	ABE kit, ABE lab guides (hardcopy and electronic), student lab report hardcopy, LabXchange Class code: E9E9CD (Tasks 1–14), micropipette quiz, ABE test