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Rice Genetic Modification Simulation

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ABE Master Teacher Fellowship Program

AMGEN® Biotech Experience

Scientific Discovery for the Classroom

The curriculum projects designed by the 2020–21 ABE Master Teacher Fellows are a compilation of curricula and materials that are aligned with the Amgen Biotech Experience (ABE) and prepare students further 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 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 curriculum pieces, please reach out to us at ABEInfo@edc.org. We will be happy to connect you with the author and provide any assistance needed.

Curriculum Project Presentations by Angela M. Del Toro
Puerto Rico ABE Master Teacher Fellowship

Class: Biology, Ecology

Grade Level: Secondary level, grades 9–12 (can be adapted to any other school grade by raising the level of the scientific method to be taught)

Concepts: genetically engineered, genetically modified (GM), genetically modified organism (GMO), DNA, rice crop, scientific method.

Topic: Genetic engineering experience

Expected Outcomes:
Students will understand:
- Genetic modification is real and could be used for the benefit of humanity.
- Relevant traits of organisms (for example, rice) can be modified in different ways (for example, disease resistance and growth capacity).
- Identify the different parts of the method and instruments needed for genetic intervention
- Knowing the principles, students demonstrate during the hands-on and virtual exercises how to handle the instruments

Students have:
- A simulated experience of modifying genetic information with the purpose of increasing quality and production in rice planting
- The opportunity to roleplay as “scientists" who will identify the different parts of the process and some of the instruments needed for genetic intervention; knowing the principles, they demonstrate during the hands-on and virtual exercises to handle the instruments

Other observable behaviors:
  - Ability to correctly manipulate laboratory materials and instruments
  - Ability to interpret data from observations
  - Understand the principles of biotechnology
  - Effective teamwork
  - Intrinsic motivation to achieve autonomous learning

Estimate Time: Three (3) months (may vary according to student learning)

Biology Class: Unit B.1: The Nature of Science (Biology)

Strategy based on Puerto Rico Standard Curriculum:
- ES.B.CB1.EM.2 –(Interactions and energy) Analyzes the structure of DNA and RNA molecules, and their replication by means of three-dimensional models.
- ES.B.IT1.IT.2 – (Engineering design) Identifies a possible solution to a real and complex problem, dividing it into smaller, more manageable problems that can be solved using engineering knowledge.

Activity Title: Project Based Learning (PBL) Rice Genetic Modification Simulator

Introduction: Genetic modification is a relevant topic of biotechnology that will allow students to learn something different and interesting, using ABE labs. Currently, genetic modification topic is not part of Puerto Rico's Department of Education science teaching curriculum, even though it is a commonly discussed and found topic in our daily life as consumers.

Secondary school students are in the ongoing process of discovering their vocational interests relating to their future career choices. Therefore, a project-based learning experience like this one will provide a significant opportunity of exposure to general genetic engineering concepts and biotechnology resource methods and procedures. On the other hand, rice is one of the most important ingredients in Puerto Rican traditional cooking (also in many other countries as well); thus, planned activities should keep students focused on the biotechnology-related activities in this curriculum.

Advances in rice biotechnology involving genetic transformation have led to many improvements in the production of rice. My goal is to provide students with a more authentic science learning experience with the equipment and process offered by the Amgen Biotech Experience (ABE) program.

Audience: The target groups will be grade 10 students, although the curriculum can be adapted to grades 11 and 12. Special-education students who are integrated into regular science courses could also be included.

Content Framework: The natural sciences are disciplines directed toward the search and construction of knowledge based on scientific methodology. Science is both a field of study and one of the ways we obtain knowledge and come to better understand the world around us. We use science every day in problem-solving and decision making. Emphasizing research in science teaching promotes the development of citizen scientists who will investigate the world. This curriculum focuses on nine high-level critical-thinking processes and skills:

These are:
- Ask questions and define problems
- Develop and use models
- Plan and conduct experiments and investigations
- Analyze and interpret data
- Use mathematical and computational thinking
- Propose explanations and designs solutions
- Expose arguments based on reliable evidence
- Obtain, evaluate, and communicate information
- Group under the same class the facts, processes, or phenomena (classification)

One of the most interesting ways to integrate a curriculum is by associating subjects that share content or whose components can be easily integrated with each other, such as science, technology, engineering, and mathematics (STEM). There are five main characteristics that must be present for an integration to be fully manifested (i.e., so that it is a real integration and not just a coincidence that the contents of one subject can be seen in another):
1. The content and exercises of one subject define the learning objectives of another.
2. Engineering or technology acts as an integrative subject of practice or is an intentional component of the content to be learned by students.
3. Engineering or technology exercises require the use of knowledge of the natural sciences or mathematics.
4. The development of skills or competencies for the 21st century is emphasized.
5. The context of instruction requires real-life problem solving.

Unit plans: The lesson plans are organized into discrete units. Students will:

1. Carry out a hands-on or virtual (using LabXchange platform) GMO simulation of rice seed
2. Create an indoor (classroom) hydroponic rice paddy in plastic pools, one using distilled water and another using tap water (scientific method)
3. Gain the real-life experience of collecting the mature rice crop from the field, in coordination with RiceTec Company (https://www.ricetec.com) and the Agricultural Experiment Station of the University of Puerto Rico, Mayaguez Campus (https://scholar.uprm.edu/handle/20.500.11801/1)

In this activity, the classroom will be divided into seven teams of five students. (Teams may vary according to the number of students in the classroom; you can place as many students in a team as you like). Each team will have a workbook (Classroom Notebook) on their computers where all team members will work at the same time. Each day is designed for 60 minutes of class, which can be adapted. The topics or activities may take longer or less time, depending on the level of learning of each group. The final activity will last about 3 months, the time it takes for the rice crop to grow and for students to monitor planting constantly to maintain ideal land for development.

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Main idea: Each student will have the opportunity to experience and work with a genetic engineering simulator.	**Science strand:** Genetic Engineering and Earth Science Scientific Method	**Level:** Secondary **Year:** 2021–22

Overarching learning outcomes:

In building understanding of genetic engineering, students will integrate:

- Reading comprehension (critical-thinking skills), cause and effect
- Instrumentation management of a biotechnology laboratory
- Pertinent and inherent questions
- Research skills about genetic engineering
- Scientific knowledge to be applied to rice planting process

In building understandings about genetic modification, students will integrate:

- Understanding that the nature of experimentation must include making predictions, observing, recording results, and drawing conclusions

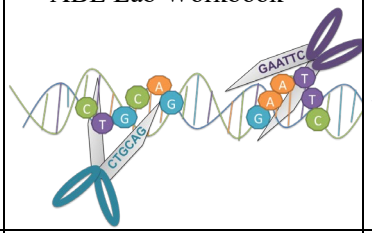
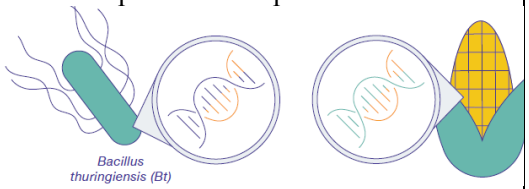
Conceptual learning outcomes	**Procedural learning outcomes**	**Nature of science outcomes**	**Technical learning outcomes**
Students will understand and apply to different situations: • Reading comprehension (critical-thinking skills), cause and effect • Rice planting process • Use of basic measurement concepts	Students will be able to: • Identify genetic characteristics of rice that can be modified • Understand the importance of rice for future survival of humanity • Improve relevant traits of organisms (disease resistance, growth capacity, shortest harvest period) • Become a citizen scientist through simulated genetic intervention Observable behaviors: • Ability to correctly manipulate laboratory material and instruments • Ability to interpret data from observations • Understand the principles of biotechnology • Effective teamwork • Quantity and quality of the product	Students will understand and appreciate that they can: • Make predictions and then test to evaluate outcomes • Use observation and describe what they see • Use basic measurement concepts • Change their ideas over time as they find and make sense of new modification	Students will be able to: • Master of the online tools in LabXchange • Master the process and understand what is needed for the rice plantation process after doing the simulated genetic variation • Use basic laboratory instrumentation and correct processing in person

Assessment:

- Guided research investigation with instructor
- LabXchange assessment
- Participation in the 9th Science Symposium
- Simulated laboratory setup

Subtasks		**Resources**	**Planned interactions**	**Key student outcomes**
Meso tasks	**Micro tasks**			
Days 1 & 2 Reading Comprehension Using Persuasive Article: ***Feeding the World***	The need for food	Moore, D. W., Short, D. J., Tatum, A. W., Tinajero, J. V., & Bernabei, G. (2013). *Inside 2014 C: Reading & language student book (2nd ed.)* [E-book]. National Geographic School Pub, p. 542–547	• Describe the problem. Open ideas.	• Find out why more food must be raised to combat hunger.
	New technology can help protect against hunger.		• Debate to find more information to choose a position regarding genetic engineering. o Pro: "I think the idea of genetically modified food has given some countries hope for solving their hunger problem." o Con: "I think genetically modified food may be dangerous. We don't know the effects of eating some of these foods."	• Find out how technology combats hunger.
	Is genetically modified food a good way to feed the world?		• Continue with debate to find more information to choose a position regarding genetic engineering.	• Learn why people oppose genetically modified food.
Days 3 to 5 Biotechnology Theory and Research	Modern biotechnology	• Internet research https://www.prabia.org/agricultura-moderna	• Each team will investigate this topic. • Draw a Venn diagram to compare and contrast modern and ancient agriculture in your laboratory notebook.	• Make a comparison between ancient vs. modern biotechnology.
	Agricultural biotechnology	• Internet research • https://www.prabia.org/agbio-espanol	• Discuss the meaning of biotechnology and agricultural biotechnology.	• Master technology-related vocabulary.
** Depending on the students' learning, you can take another day or review it**	The rice	• https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/GMOs/GMOs.html	Discuss: • Importance of rice cultivation • How is rice cultivated? • Genetic transformation of rice (GMO)	• Identify what rice quality you think is important to modify.

Subtasks		Resources	Planned interactions	Key student outcomes
Meso tasks	**Micro tasks**			
			• Discuss characteristics that have been modified or improved in rice through genetic transformation	
Days 6 &7 Biotechnology Theory and Research (cont.)	The structure of DNA, genes, and the genetic code	• LabXchange • https://n9.cl/nctun • https://bit.ly/2XRGmhR	• Interpret the instructions written in the DNA.	• Know the function, structure, and interpretation of genetic codes.
	Genetic engineering	LabXchange • https://n9.cl/cocti	• What are examples of basic techniques used to manipulate genetic material?	• Make a list of the examples for genetic engineering or recombinant DNA techniques.
Day 8 Lab Practice 1.1: How to Use a Micropipette	Micropipette handling	• Amgen Biotech Experience Student Lab Workbook	• Practice with important tools in genetic engineering.	• Use micropipette correctly.
	Measurement concepts: Volume		• Know the volume measurements.	• Correctly perform the volume measurements using the instrument.
	Laboratory technique		• Use a micropipette practice sheet and record volume measurements as written.	
Day 9 Lab Practice 1.2: How to Use Electrophoresis	Review of volumes	• Amgen Biotech Experience Student Lab Workbook	• Use a micropipette and electrophoresis.	• Correctly perform the volume measurements of the instrument.
	Electrophoresis management		• Practice with an important tool in genetic engineering on an agarose petri dish.	• Correctly use electrophoresis without breaking gels (by using a simulator).
Day 10 & 11 Laboratory Practice 2.1 Preparation for genetic modification	Crop modification	• Amgen Biotech Experience Student Lab Workbook • https://cdn.agclassroom.org/media/uploads/2017/09/1	• Research how GMOs are created	• Understand key traits, such as resistance to pests (abiotic factor) or whatever trait you chose to modify (depending on the investigation question).

Subtasks		Resources	Planned interactions	Key student outcomes
Meso tasks	**Micro tasks**			
		5/How_to_Create_a_GMO_ISN.pdf		
	Identify the gene	• https://agclassroom.org/matrix/lesson/598/ Very useful if you want to change the grade level	• Identify the gene or genetic material that could solve a problem like resistance to pest.	• Study genetic makeup of the plant that needs the trait.
	Copy the trait	• ABE Lab Workbook 	• Copy the trait from the donor organism and implant into the plant's DNA. 	• Know that transformation is a process by which a copy of genetic material from a specific trait is inserted into the cells. • Practice real electrophoresis.
Day 12 Final Step- Plant the seeds.	Seedbed preparation	• https://www.wikihow.com/Grow-Rice • https://www.jica.go.jp/activities/issues/agricul/approach/ku57pq00002m21du-att/handbook_01.pdf	• Substrate preparation • Preparation of trays • Seedbed preparation • Sowing method	• Leave the clay and acid soil of the seedbeds.
Day 13 to Test the resulting plants	Observe planting ground	• Follow rice cultivation handbook.	• Check if the first leaves grew to lower the flood levels so that they breathe. • The blade should stick out of the water. • Begin to let the soil dry.	• Waiting for them to grow selects the healthiest and strongest seedlings. • stand on a muddy bed.

Verification of learning: Use of rubrics of the presentations, the handling of the instrumentation, and work in the laboratory; lab reports with results; use of LabXchange to learn through simulation before working in person; student reflections

Delivery methodologies: Theoretical and practical classes offered before students begin virtual practice through LabXchange laboratories before working in-person; learning by doing, hands-on labs, small-group activities.

Resources and references: Sources of information or teaching methods

Teaching methods: High-tech approach to learning
From devices like laptops and tablets to using the internet to connect students with information and people from around the world, technology plays an ever-greater role in many of today's classrooms. In the high-tech approach to learning, teachers use many different types of technology to aid students in their classroom learning. During this unit, students will benefit from these advances in technology through the use of LabXchange, simulations and other virtual resources, and come to a more complete understanding of biotechnology

Sources:

Amgen Foundation. (2019). *Student lab manual.* https://amgenbiotechexperience.com/sites/default/files/abe-student-lab-manual.pdf

Genetically Modified Organisms. (2013). *Background*. Boston University. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/GMOs/GMOs2.html

Fiaz, S. (2019). *Applications of the CRISPR/Cas9 system for rice grain quality improvement: Perspectives and opportunities*. MDPI. https://www.mdpi.com/1422-0067/20/4/888/htm

National Center for Case Study Teaching in Science. (2017, December 30). *How to make a genetically modified plant* [Video]. YouTube. https://www.youtube.com/watch?v=JtkhHIG3nx4

Rahman, M., Milu, R. D., & Das, R. (2021). Abundance of hetrocystous blue green algae of rice field of Mangaldoi Sub Division, Darrang District Assam. *Bioscience Biotechnology Research Communications*, *14*(5), 242–244. https://doi.org/10.21786/bbrc/14.5/43

RiceTec, Inc. (2021, September 14). *Hybrid rice seeds home - RiceTec, Revolutionizing rice production*. https://www.ricetec.com

Terazono, T., & Cookson, C. (2019, March 6). *Gene editing: How agritech is fighting to shape the food we eat*. SmartFarm The30F. http://www.the30f.com/gene-editing-how-agritech-is-fighting-to-shape-the-food-we-eat/

Wellcome Genome Campus. (2021). *What is a GMO?* LabXchange. https://www.labxchange.org/library/items/lb:LabXchange:ca916ca2:html:1

