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**Manipulating Biology**

**Unit Title**: *Feeding the World Using GMOs: Morally Required or Morally Reprehensible?*

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**Introduction**

William Penn High School is a public high school in the Colonial School District in New Castle County, DE. It is the only high school in the district and it is the largest high school in the state of Delaware, serving approximately 2,200 students grades 9-12. The school district is mostly suburban, with small portions of the district being considered urban (the far northern portion of the district pulls from southern Wilmington) and some being considered rural (the far southern portion of the district pulls from farmland situated on either side of the Chesapeake and Delaware Canal. In total, the district serves over 10,000 students and expects to increase in size as the New Castle area experiences is revitalized by industry and job growth.

In order to make every student college and career ready, William Penn High School is divided in three college academies: the STEM College Academy, the Humanities College Academy, and the Business College Academy. Each college offers majors, or pathways of study. Incoming students decide on a pathway of study and must earn three consecutive credits related to that pathway as a requirement for graduation. AP Environmental Science (APES), the course for which this unit will be written, is the capstone course for the Environmental and Natural Resources (ENRS) pathway. Students in the ENRS pathway take Introduction to Agriscience, Natural Resources and Ecology, and Environmental Science Issues. The motivation behind this pathway is to provide students with access to the content knowledge and career skills necessary to continue on to study environmental science in their post-secondary education and/or to be ready to enter the environmental workforce upon graduation. To that end, students in this pathway get field experience, four credits of environmental science, and access to internships in related fields. The ENRS program at William Penn is uniquely positioned to take advantage of several educational resources, including the school’s chemistry and biology labs, a multi-acre farm operated by the district (Penn Farm), an aquaponics facility, a greenhouse, and partnerships with higher educational institutions and local businesses.

**Rationale**

I have produced two units through the Delaware Teachers Institute (DTI) – one for Chemistry and one for APES. I have also produced a unit for APES through the Yale National Initiative (YNI). My participation in DTI and YNI has increased my content knowledge, increased student engagement in the classroom, and raised the rigor of both of my courses. Through my participation in the seminar on Manipulating Biology, I hope to develop a unit focusing on the use of Genetically Modified Organisms (GMOs) while also increasing students’ scientific literacy and interest in understanding how and where their food is produced. I also hope to further integrate the Next Generation Science Standards (NGSS) 3-Dimensional Model of science education into my AP course.

 The current population of the planet is roughly 7.4 billion people. Of these 7.4 billion people, 1 billion are considered to be chronically undernourished. By the year 2050, there will be at least 2.5 billion additional people on the planet, and most of these people will live in regions where chronic undernourishment and famine are already problematic. What’s more is that the amount of arable (farmable) land on the planet has already been maximized and even begun to decline, especially in arid and semi-arid regions where food shortages are a stark reality. These two problems are made even worse by the fact that they are intricately linked: more people requires more food, more food requires more land, more land is not available, more food is not available, people go hungry. And to make an already dire situation worse, scientists have predicted that such regions will receive less rainfall in more sporadic patterns. It is vital that the next generation of voters/consumers/scientists understand the magnitude of the global food crisis and its interconnectivity with climate change. This newly developed unit that enhances my Land Use and Agriculture section of APES is my first step toward helping my students achieve that understanding. In this unit, students will engage with a variety of texts and digital media, develop a scientific understanding of what GMOs are and how/why/where they are being used. Additionally, this unit will be enriched by students engaging in learning activities with Penn Farm, the University of Delaware, and DuPont Pioneer. After completing the unit, students will have an advanced understanding of GMOs and their role in feeding the world.

**Objectives**

There are several course objectives and aspects of the three dimensional NGSS that I will address in this unit. Specific to the course, students will learn that: (1) food production needs to be doubled by 2050 to meet the demands of a growing population, (2) the amount of arable land on the planet has peaked and begun to decline, (3) genetic modification is a more refined version of selective breeding that focuses on altering/inserting/deleting specific genes, and (4) GMOs are a viable option for feeding a growing population, but their environmental and health impacts need to be more carefully studied.

 These objectives will be met through three-dimensional NGSS instruction that includes the following Science and Engineering Practices (SEPs): developing and using models, using mathematical and computational thinking, constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information. The last two practices are also objectives of the Common Core State Standards to have students integrate information from various sources and synthesize written or verbal arguments. With respect to standards, this unit will address the following topics required by the College Board: II-C-3-Natural Selection, II-C-4-Biodiversity, IV-A-1-Feeding a Growing Population, IV-A-2-Controlling Pests, and VII-C-1-Loss of Biodiversity. Additionally, the following NGSS Disciplinary Core Ideas (DCIs) will be addressed: HS-LS3-2: Inheritable genetic variations arise in different manners, HS-LS4-5: Changing environmental conditions favor those most fit for such changes, and HS-LS2-2: Various factors affect biodiversity and populations in ecosystems of different scales. The following Cross-Cutting Concepts (XCCs) will be used to frame instruction: structure and function, cause and effect, and systems and systems models. By integrating the SEPs, DCIs, and XCCs into instruction, students will be doing more than just remembering a set of facts concerning GMOs. Instead they will be engaging in real scientific processes centered on the phenomenon of feeding a growing population with fewer land resources. This method of instruction will increase long-term retention of information and translate into better performance on unit exams as well as the AP exam. In addition, it will allow students the academic freedom and flexibility to learn in a way that both challenges them and suits their educational needs.

**Key Concepts**

Students will understand that:

* Genetic modification of organisms is a more precise version of the selective breeding used for tens of thousands of years in traditional and modern agriculture.
* Genetic modification can increase crop yields even in the face of diminishing agricultural land resources by making crops more tolerant of a variety of stressors (pests, weeds, drought, salinity, etc.).
* Use of GMOs in certain places will make crops more profitable by reducing the need for fertilizers, pesticides, herbicides, and/or irrigation).
* Any threats to the environment uniquely posed by the use of GMOs, such as gene transfer, are not well understood in the scientific community and require more research.
* Human consumption of GMOs (or animal products raised on GMOs) is largely considered safe in the scientific community.

**Essential Questions**

In keeping with the Learning Focused model of planning and delivering content, students will work towards answering the following Lesson Essential Questions (LEQs) throughout the unit:

1. How is something that has been genetically modified different from something that has been selectively breeded?
2. How can GMOs be used as part of sustainable farming practices throughout the world?
3. What are the economic and moral arguments for and against the use of using GMOs to feed the world?

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