AMGEN Biotech Experience

Scientific Discovery for the Classroom

Exploring Precision Medicine

TEACHER GUIDE

2026 Pilot

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CURRICULUM OVERVIEW

INTRODUCTION

You have been granted the unique opportunity to integrate the Amgen Biotech Experience (ABE) into your classroom. Students will benefit by augmenting their scientific knowledge and skills while gaining experience with current, real-world biotech applications. This guide details the science content, teaching and learning principles and practices, and practical considerations for implementing the course. Please read this section before you begin to enhance your teaching and improve your students' experience.

The ABE *Exploring Precision Medicine* curriculum module was designed to be implemented in a wide range of secondary classrooms. This module builds students' biotechnology knowledge and engages them through real-world scenarios that reflect authentic scientific practices. It begins with a scientific conundrum for students to consider, ultimately guiding them to develop their own thoughts and insights about the problem. The module incorporates real data, scientific papers and articles, and videos to provide students with an authentic experience working as scientists.

TEACHER NOTE: This module addresses the performance expectations in the high school-level Inheritance and Variation of Traits topic of the U.S. *Next Generation Science Standards* (NGSS) as well as some performance expectations in the Natural Selection and Evolution and Structure and Function topics. For specifics, see **Appendix A.**

OVERVIEW OF THE CONTENT

This curriculum module explores the concept of ***precision medicine*****,** an emerging approach to health management that identifies treatment and prevention strategies for a person based on their genetic, environmental, and lifestyle factors. ***Pharmacogenomics***—the study of how ***genes*** affect a person's response to drugs—is part of precision medicine.

In this module, students will use a case study, readings, videos, and laboratory exercises to investigate how our genes influence both outwardly visible and invisible traits. They will be introduced to the idea that medicines do not work the same way for everyone by examining a case study of a patient whose doctor proposes genotyping to reduce potential side effects from their necessary medication while reviewing some of the science that makes this approach possible.

Students will also learn about variation in ***genotype*** (an individual's genetic makeup) and ***phenotype*** (an individual's observable characteristics) using the example of ***phenylthiocarbamide (PTC)*** tasting ability—a trait that differs significantly from person to person and is analogous to the trait for medication metabolism. In the activity that follows, students will explore their own bitter-tasting abilities by rating foods and tasting PTC test papers (which are used to test for the genetic ability to experience a type of bitter taste). Then, students will extract their own genomic DNA and use a ***polymerase chain reaction (PCR)*** to amplify a specific portion of the DNA.

Students will learn more about the history and theory of ***DNA sequencing***, use software to align and analyze genetic sequences, and learn more about how ***single nucleotide polymorphisms (SNPs)*** (pronounced "snips") can change an individual's phenotype, as is the case with PTC-tasting ability. They will determine which restriction enzyme will allow them to cut their amplified DNA to differentiate the various genotypes. Students will use ***gel electrophoresis*** to examine their DNA and to confirm their taster genotype.

Finally, students will revisit the connection between genes and drug metabolism by revisiting the patient case study to discover that the patient's genotype renders them ineligible for a particular prescription medication.

This module begins to build the knowledge necessary to meet the following NGSS Performance Expectations:

- HS-LS1 From Molecules to Organisms: Structures and Processes
- HS-LS3 Heredity: Inheritance and Variation of Traits

Students will also build on their learning of the following science and engineering practices:

- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

RECOMMENDED BACKGROUND KNOWLEDGE

Students should complete *Foundations of Biotechnology* before this module to ensure they have experience with molecular biology tools and techniques, including pipetting, centrifuge, gel electrophoresis, and restriction enzyme digestion. They should also be familiar with basic concepts of genetics, heredity, and cell and molecular biology.

USING THIS MODULE

Exploring Precision Medicine includes this Teacher Guide, a Student Guide, student worksheets (termed "reproducible masters" [RMs]) with answer keys, and teacher slide decks for each chapter. For the optimal student learning experience, please review the suggestions that follow.

Teacher Guide and Slides: Each chapter of this Teacher Guide includes background information, lists of necessary reagents and equipment, protocols for the "wet labs," learning goals, links to resources such as articles and videos, and suggested teacher scripts (see below). Additionally, there is a separate slide presentation for each chapter.

Each lesson is organized around the "5E" instructional model, which is widely used in science instruction in North America. In brief, its components include:

- **Engage:** An opportunity to capture students' interest, assess their prior knowledge, and frame the central concept of the lesson

- **Explore:** The hands-on portion of the lesson, consisting of lab work, reading articles, screening videos, use of analytic software, etc.
- **Explain:** Interactive discussion to help students connect their prior knowledge to new understandings they have gained through exploration
- **Elaborate:** An opportunity for students to extend their knowledge to new situations, for example, by researching a concept online
- **Evaluate:** Formal assessment of student learning (Note that the Teacher Guide does not include the Evaluate step of this model yet)

The teaching procedures are presented in table format within the Teaching Sequence section of each chapter. The left-hand column includes either teacher instructions (in plain text) or a suggested script (in italics), along with references to corresponding slides. The right-hand column includes expected student responses and supporting information. Important Teacher Notes span the width of the table (see example below).

Teacher Instructions *Suggested teacher "script" appears in italics.*	**Expected Student Responses** Additional information may be provided.
1. Teacher instructions appear here. *Suggested script appears here.* **Slide Reference**	• Expected student responses • Supporting information
TEACHER NOTE: Important information appears here.	

The slides are designed to be presented alongside the teacher script, and the videos mentioned in the text are embedded within them. Additional information for teachers appears in the slide speaker notes. Optional slides are hidden and referenced accordingly; feel free to use these for further elaboration or enrichment. In some cases, such as in Chapter 2, blank data tables are provided and can be projected onto a whiteboard, chart paper, or smart board to facilitate capturing student data.

Student Guide: The Student Guide may be printed or shared in digital form. Students can scan the provided QR code to access videos, articles, and DNA sequence files. Important links and resources for student, accessible via this QR code, will be updated regularly with new or revised links as well as corrections to errata.

Reproducible Masters and Answer Keys: Reproducible masters for each chapter are listed in the Preparation section and can be accessed on the *Exploring Precision Medicine* webpage. You may photocopy and share these with students. Please note that some activities are assigned to groups. You may opt to have student groups submit a single reproducible master or have each student complete their own. If you wish to provide digital versions (e.g., as Google Forms), you may create them by reproducing the content from your copy of the reproducible masters.

SEQUENCE OF ACTIVITIES

CHAPTER 1: WHAT'S THE RIGHT MEDICINE?

By exploring the fictitious case of a patient whose doctor screens them to reduce potential negative side effects from the antiplatelet drug clopidogrel (brand name Plavix), students draw connections between an individual patient's physiological variability and their genetic makeup. This introduces the concept of precision medicine—the idea that treatments should be tailored to individual patients rather than an "average" patient.

CHAPTER 2: IS MY SENSE OF TASTE CONTROLLED BY MY GENES?

Students log whether vegetables in the *Brassica* genus taste bitter to them, then learn how variations in the TAS2R38 gene determine whether they can taste PTC. Students connect this exploration of genotype and phenotype to the patient in Chapter 1.

CHAPTER 3: EXPLORING OUR DNA

Students extract their own DNA from their cheek cells (at sites where this is feasible). They use PCR to isolate and amplify a specific segment of their own TAS2R38 gene to help determine their taster genotype.

> **TEACHER NOTE:** At sites where students may not use their own DNA, template DNA will be available.

CHAPTER 4: HOW IS DNA SEQUENCED, AND WHAT CAN WE LEARN?

Students use bioinformatics software to compare two TAS2R38 sequences to determine how they differ. They explore how the various genotypes relate to the taster phenotypes and discuss how small the differences are between the DNA sequences. They also explore a DNA chromatogram to learn what a heterozygous DNA sequence looks like.

CHAPTER 5: RESTRICTION ENZYME DIGESTION OF TAS2R38 PCR PRODUCTS

Students will perform a restriction enzyme digest on their PCR products to differentiate between homozygous taster, heterozygous taster, and homozygous nontaster genotypes.

CHAPTER 6: GEL ELECTROPHORESIS AND GENOTYPING

Students will use gel electrophoresis to visualize the results of their restriction digest and compare their taster genotype to their PTC paper taste test.

CHAPTER 7: SNPS AND DRUG METABOLISM

Students will relate what they've learned through their exploration of PTC tasting and SNPs to better understand the role of genetics in drug metabolism and response. Specifically, they will explore the role genetic variation plays in metabolism of clopidogrel, thus connecting their findings back to the original case study. Finally, students will consider the pros and cons of using genetic information to better treat patients.

TEACHER NOTE: This module explores pharmacogenetics to help students understand the subtle ways minor differences in human DNA can manifest. The module is not meant to stress differences between *races* of people; however, students may perceive that genetic differences are correlated with race because of how often the literature refers to the effectiveness of drugs based on the social construct of race.

It is important to point out that genetic differences between people of the same race are often greater than genetic differences between people of different races. Scientists often use the social construct of race to quantify genetic differences because it is a simple way to describe these differences. Genetic commonalities are most likely due to lineage (having common ancestry). It may also help to explain to students that people of the same race often share genetic similarities because their common ancestors came from the same part of the world. As human beings migrate and intermingle globally, differences between races become less pronounced. For further information, please refer to **Appendix B**.

MATERIALS PREPARATION

Before you begin, you should become familiar with the lesson plan in each chapter, the preparation required, and the materials you'll need. **Pay special attention to the requirement for a student consent form, which must be completed in advance of Chapter 3.** Each student should have a Student Guide along with any required "reproducible masters" (i.e., worksheets). In addition, each student should have a personal science notebook for recording experimental observations and notes. Materials listed in each chapter are based on teams of four. Materials needed for the entire module are listed in **Appendix C.**

Each lab in this guide will require:

- Chart paper and markers, or a whiteboard and whiteboard markers
- For the instructor/presenter: a computer with a large-screen monitor or projector
- For the wet labs: a waste container (ideally, at least one small tabletop or countertop waste container for every two to four students)

Hardware requirements: While students may use smartphones, tablets, laptops, or desktop computers to program thermocyclers for the Chapter 3 labs, students are strongly encouraged to use laptops or desktop computers with internet access for the nucleotide and amino acid sequence alignment activities in Chapter 4 as well as the simulated restriction enzyme digest activity in Chapter 5. In Chapter 7, there is an optional Elaborate activity in which students research genetic variations that affect medication metabolism; this activity can be carried out on a tablet, laptop, or desktop computer.

TEACHER NOTE: For optimal results in the wet labs, keep all reagents on ice or in a labtop cooler. For PCR, the One*Taq*® Hot Start 2X Master Mix with Standard Buffer is stable at room temperature for up to 7 days, according to the manufacturer. While the enzyme is stable for a long time, the dNTPs in the Master Mix will degrade over the course of a few days.

TIMING SUGGESTIONS

Exploring Precision Medicine comprises seven chapters for a total of 11–15 class periods, each lasting 50 minutes. **To condense the timeline, some "dry lab" activities, such as readings, can be assigned as homework, and sections labeled as "optional" may be skipped.** However, plan for wet labs to require all available bench time.

CALENDAR

Please note that in the tables below, chapters in cells with background shading are "wet labs" (where students carry out hands-on experiments), and unshaded cells are "dry labs" (where students work on paper and/or computers).

Standard Implementation

Day 1	**Day 2**	**Day 3**	**Day 4**
Chapter 1 What's the Right Medicine?	**Chapter 1** (cont'd)	**Chapter 1** (cont'd)	**Chapter 2** Is My Sense of Taste Controlled by My Genes?
Day 5	**Day 6**	**Day 7**	**Day 8**
Chapter 2 (cont'd)	**Chapter 3** Exploring Our DNA	**Chapter 3** (cont'd)	**Chapter 4** How Is DNA Sequenced, and What Can We Learn?
Day 9	**Day 10**	**Day 11**	**Day 12**
Chapter 4 How Is DNA Sequenced, and What Can We Learn?	**Chapter 4** (cont'd)	**Chapter 5** Restriction Enzyme Digestion of TAS2R38 PCR Products	**Chapter 5** (cont'd)
Day 13	**Day 14**	**Day 15**	
Chapter 6 Gel Electrophoresis and Genotyping	**Chapter 7** SNPs and Drug Metabolism	**Chapter** 7 (cont'd)	

Shortest Implementation

Day 1	**Day 2**	**Day 3**	**Day 4**
Chapter 1 What's the Right Medicine?	**Chapter 1** (cont'd)	**Chapter 2** Is My Sense of Taste Controlled by My Genes?	**Chapter 3** Exploring Our DNA
Day 5	**Day 6**	**Day 7**	**Day 8**
Chapter 3 (cont'd)	**Chapter 4** How Is DNA Sequenced, and What Can We Learn?	**Chapter 4** (cont'd)	**Chapter 5** Restriction Enzyme Digestion of TAS2R38 PCR Products
Day 9	**Day 10**	**Day 11**	
Chapter 6 Gel Electrophoresis and Genotyping	**Chapter 6** (cont'd)	**Chapter 7** SNPs and Drug Metabolism	