

# PLTW | Biomedical Science

## Principles of Biomedical Science

2015-2016 Course Outline





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*It was a hot summer morning. A man contacted the police to report that he was worried about his next-door neighbor, a woman named Anna. He tried to call Anna on the telephone, but no one answered. Both the police and an EMT arrived at the scene. The EMT soon determined that Anna was dead. The police immediately notified your team of crime scene investigators as well as the medical examiner, both of which were dispatched to the house. Your job is to determine what happened to Anna.*

From the moment students walk into the Principles of Biomedical Science (PBS) classroom, they are immersed in the mysterious death of Anna. They are asked to investigate, document, and analyze evidence to solve the case.

The Principles of Biomedical Science (PBS) course provides an introduction to biomedical science through exciting hands-on projects and problems. Students investigate concepts of biology and medicine as they explore health conditions including heart disease, diabetes, sickle-cell disease, hypercholesterolemia, and infectious diseases. They will determine the factors that led to the death of a fictional woman as they sequentially piece together evidence found in her medical history and her autopsy report. Students will investigate lifestyle choices and medical treatments that might have prolonged the woman's life and demonstrate how the development of disease is related to changes in human body systems.

The activities and projects in PBS introduce students to human physiology, basic biology, medicine, and research processes and allow students to design experiments to solve problems. Key biological concepts, including maintenance of homeostasis in the body, metabolism, inheritance of traits, and defense against disease are embedded in the curriculum. This course is designed to provide an overview of all the courses in the biomedical science program and lay the scientific foundation for subsequent courses.

Students practice problem solving with structured activities and progress to open-ended projects and problems that require them to develop planning, documentation, communication, and other professional skills.



The following is a summary of the units of study that are included in the course. Alignment with Next Generation Science Standards, Common Core, and other standards are included in the curriculum. Activities, projects, and problems are provided to the teacher in the form of student-ready handouts, teacher notes, and supplementary materials, including resource documents, student response sheets, and presentations.

### **PBS Unit Summary**

Unit 1.....	The Mystery (20%)
Unit 2.....	Diabetes (25%)
Unit 3.....	Sickle Cell Disease (15%)
Unit 4.....	Heart Disease (25%)
Unit 5.....	Infectious Disease (10%)
Unit 6.....	Post Mortem (5%)

## **Unit 1: The Mystery**

The goal of Unit 1 is to provide the foundation and develop the theme for the course. Students are engaged by reading about a woman, Anna Garcia, who is found dead in her home. Students investigate the scene, gather evidence, and then move to the lab to analyze their findings. Through their examination of key evidence, students learn notebook organization, observation and documentation skills, and the fundamentals of experimental design. Students are introduced to the structure of DNA and investigate how basic molecular biology techniques can be used to connect suspects with a crime scene. Students also discuss the bioethics of scientific research and explore the bounds of HIPAA legislation. In each unit of the course, students obtain additional medical history information for Anna as well as details from her autopsy report as they explore the various illnesses she encountered throughout her life. Students will maintain a medical file for Anna Garcia, compile their ideas and findings over the duration of the course, and ultimately determine her cause of death in the final unit.



## **The Mystery Lesson Summary**

Lesson 1.1.....Investigating the Scene

Lesson 1.2.....DNA Analysis

Lesson 1.3.....The Findings

### **Lesson 1.1 Investigating the Scene**

The goal of this lesson is to lay the foundation for the course and introduce students to the use of laboratory and career journals and Inspiration® software. Students also learn how to set up an experiment and how to properly document sources. The lesson opens with the mysterious death of Anna Garcia. Students play the role of crime scene investigators to examine key information gathered from interviews of friends, family members, and people of interest. In addition students examine the scene for clues. Next they play the role of forensic scientists to analyze each piece of evidence collected from the crime scene, including hair, fingerprints, blood, and shoeprints in order to determine what happened at Anna's house and to identify potential suspects. Students will learn how to design an experiment while determining how ambient temperature affects the cooling rate of a dead body. Finally, they will design and perform an experiment to investigate how height affects bloodstain patterns. Students will use the results to identify the height that caused the bloodstain patterns found at Anna's house in order to determine whether she might have been struck standing up or as she was falling.

### **Lesson 1.2 DNA Analysis**

In the last lesson, students processed and analyzed evidence found at Anna Garcia's house at the time of her death, including blood samples found near her body. In this lesson students will explore DNA in order to determine whose blood was found at the scene. Students will begin to explore the relationship between DNA, genes, and chromosomes. They will extract DNA from both plant and animal cells, investigate the structural composition of DNA by building a three-dimensional model of the molecule, explore the methods used to analyze DNA, and then work as a forensic DNA



analyst to compare the DNA found at the crime scene with the DNA obtained from each of the suspects.

### **Lesson 1.3 The Findings**

In the previous lessons, students were introduced to the case of the mysterious death of Anna Garcia. They investigated the crime scene, analyzed the evidence, and performed DNA profiling. In this lesson students will investigate autopsy procedures and will be given the first piece of Anna's autopsy report. They will put together all of the evidence collected and analyzed regarding Anna's mysterious death throughout the unit in order to draw conclusions and create a report detailing the suspected manner of death (natural, accidental, or homicide). They will learn how to properly cite sources and investigate the role that different biomedical professionals played in Anna's mysterious death investigation. Finally students will discuss the bioethics of scientific research and explore the bounds of HIPAA legislation.

## **Unit 2: Diabetes**

The goal of Unit 2 is for students to walk through Anna Garcia's diagnosis of diabetes by completing simulated laboratory tests. Given results of the tests, students can deduce the basic biology of both Type 1 and Type 2 diabetes. Students investigate the connection between insulin and glucose and discuss how feedback systems in the body regulate the function of key hormones. Students investigate the biochemical makeup of food and complete experiments to demonstrate the relationship between energy and food. As students explore diabetes, they are introduced to basic chemistry, the structure and function of macromolecules, and the relationship of these molecules to metabolic function. The causes, symptoms, treatments, and side effects of diabetes are studied as well as the lifestyle implications associated with this disease. Students examine complications related to diabetes and finally brainstorm and develop an innovation to help with the management or treatment of the disease.

**Diabetes Lesson Summary**

Lesson 2.1 .....What is Diabetes?

Lesson 2.2 .....The Science of Food

Lesson 2.3 .....Life with Diabetes

**Lesson 2.1 What Is Diabetes?**

In this lesson the goal is for students to investigate what it means to have diabetes. Students will explore how doctors make an initial diagnosis of diabetes and characterize the disease. They will complete simulated glucose tolerance testing as well as insulin analysis on three patients, including Anna, and draw conclusions about their disease status based on your findings. By analyzing test results, they will deduce what is happening inside the body when a person has Type 1 or Type 2 diabetes. Students will further investigate the relationship between insulin and glucose and learn how to find credible sources. Students will use the design process to create a 3-D working model demonstrating how insulin works to move glucose into cells. Students will use the model to explain this process to a target audience of newly diagnosed diabetics. Students will then investigate feedback and feedback loops. Using knowledge of the insulin/glucose connection, students will diagram the specific steps in the body that function to keep blood sugar in balance.

**Lesson 2.2 The Science of Food**

The goal of this lesson is for students to investigate the science of food and look in detail at the biochemistry of macromolecules. Students will use chemical indicators to test for the presence of sugar, starch, protein, and lipids in three common food items as well as in the stomach contents of the ill-fated Anna Garcia. Students will define various terms commonly used on food labels and then analyze food labels to determine the nutritional content of the respective food items. Students will analyze Anna's diet and assess how well she was meeting her nutritional requirements. Students will then complete a series of molecular puzzles to build macromolecules and explore the biochemistry of food. They will begin to see how the body works to harness the power of what we eat through the



assembly and disassembly of macromolecules. Students further explore the energy content of various foods by completing calorimetry experiments using Vernier software and a temperature probe. Students will continue to explore how food choices are vital to the health of a diabetic in the next lesson.

### **Lesson 2.3 Life with Diabetes**

The goal of this lesson is for students to explore the personal side of life with diabetes. The lesson begins with students designing a “What to Expect” guide for patients confronted with a new diagnosis. The guide should offer insight into a typical day in the life of a diabetic and should highlight daily routines, restrictions, lifestyle choices and modifications, as well as tips for coping and acceptance. Students will further examine what happens inside the body of a diabetic as they simulate how the body reacts to varying blood glucose concentrations. Students design an experiment to simulate osmosis in body cells and attempt to match details about diabetic emergencies in Anna Garcia’s life with simulated blood serum from the time of these incidents. Students relate the movement of water in model cells to the symptoms that Anna experienced in each emergency situation. Students begin to understand how rapid shifts in blood sugar can have severe consequences. While most of these complications are short term if addressed quickly, there are many long term consequences of diabetes, especially if the disease is not well-controlled. Students will explore the impact that Type 1 and Type 2 diabetes can have on human body systems and visualize this impact on a graphic organizer. They will read additional information from Anna’s autopsy report and analyze findings to brainstorm possible causes of death. Students will then design an innovation that helps diabetics treat, manage, or even cure their disease and present their idea to a panel offering a research grant.



## **Unit 3: Sickle Cell Disease**

The goal of Unit 3 is for students to learn basic concepts of genetics and inheritance as they explore Anna Garcia's struggle with sickle cell disease. Students examine sickled red blood cells under a microscope and learn what life is like with the disease by reading and writing patient diary entries. They simulate the process of protein synthesis, examine the assembly of the protein hemoglobin, and demonstrate how sickle cell disease results from a mutation that alters a protein product. Students examine the structure of chromosomes and show how traits are passed through generations on the chromosomes in our cells.

### **Sickle Cell Disease Lesson Summary**

Lesson 3.1 .....The Disease

Lesson 3.2 .....It's in the Genes

Lesson 3.3 .....Chromosomes

Lesson 3.4 .....Inheritance

### **Lesson 3.1 The Disease**

The goal of this lesson is to introduce the students to what it means to have sickle cell disease. Students will learn about the components and function of blood in order to better understand how sickle cell disease affects the body. They will examine Anna Garcia's blood with a microscope and complete a simulated hematocrit in order to determine whether Anna's sickle cell disease was causing her other related health problems. They will learn about what it is like for a person dealing with this serious disease by reading her diary entries. Finally, they will write diary entries for a fictitious sickle cell patient. The entries will detail how the patient is feeling, describe the treatment being given, and include a narrative of all of the biomedical professionals the patient encounters during their treatment journey.

### **Lesson 3.2 It's in the Genes**

The goal of this lesson is for students to investigate how DNA codes for proteins and how mutations can lead to diseases such as sickle cell anemia. Students will explore how the body uses DNA to





produce proteins. They will apply their knowledge of protein synthesis to decode a secret message, investigate the effects that various mutations have on protein production, and look specifically at the genetic mutation that causes sickle cell disease. Students will use computer simulations to visualize the interactions between amino acids and how these relate to protein structure. They will recognize how changes in the b-globin protein are due to the mutation associated with sickle cell disease.

### **Lesson 3.3 Chromosomes**

The goal of this lesson is for students to further explore the relationship between DNA, genes, and chromosomes. Students will investigate the role that chromosomes play in transferring genetic material from cell to cell as well as from generation to generation. Students will also explore how the genes encoding dominant and recessive traits are passed through the generations via our chromosomes.

### **Lesson 3.4 Inheritance**

The goal of this lesson is for students to further study how inherited diseases are passed from parent to child, with a focus on sickle cell disease. They will analyze the gel electrophoresis results obtained from the Restriction Fragment Length Polymorphisms (RFLPs) of Anna Garcia's family members to create a family pedigree. Next they will calculate the theoretical probability of a child inheriting sickle cell disease using Punnett squares and compare the results to experimental results. Finally, they will put it all together to analyze pedigrees. As an optional extension activity, students will simulate the effects of a high frequency of malaria on the allele frequencies of a population.



## **Unit 4: Heart Disease**

The goal of Unit 4 is for students to examine the normal function of the human heart and investigate malfunctions in the cardiovascular system that can lead to heart disease. Students complete a dissection to tour heart anatomy and study heart function using probes and data acquisition software. They collect and analyze heart data, including heart rate, blood pressure, and EKG readings and analyze cardiac test results of Anna Garcia. Students explore the role cholesterol plays in the body. Students further their knowledge of molecular biology as they run gel electrophoresis and complete RFLP analysis to diagnose familial hypercholesterolemia. Students design models to simulate the function of a pump and design visuals to show interventions for blocked coronary vessels.

### **Heart Disease Lesson Summary**

Lesson 4.1 .....Heart Structure

Lesson 4.2 .....The Heart at Work

Lesson 4.3 .....Heart Dysfunction

Lesson 4.4 .....Heart Intervention

### **Lesson 4.1 Heart Structure**

The goal of this lesson is for students to explore the structure and organization of the heart. In the first activity of the lesson, students will investigate the basic structure of the heart and identify the major blood vessels that bring blood in and out of the heart's main chambers. They will create a graphic organizer to help them remember the basic blood flow pattern to and from the heart and lungs. The diagrams they draw in this activity will help them identify the actual structures of the heart when they dissect a four-chambered sheep's heart in the next activity. Students will observe key structures and discuss how structure relates to function. They will also use a microscope to observe the structure of arteries and veins. At the conclusion of the lesson, students will review Anna's autopsy report and begin to postulate how problems in the cardiovascular system may have contributed to her death.



## **Lesson 4.2 The Heart at Work**

The goal of this lesson is for students to learn how the heart works in order to understand how and why heart disease occurs. Students learn that because of a few episodes of chest pain, Anna Garcia was sent for a full cardiac workup. Students will learn about the tests used to monitor heart function and use data acquisition software and probes to study heart rate, blood pressure, and electrical activity of the heart. Students will design and conduct experiments on variables affecting heart rate and blood pressure and document their work in a formal laboratory report. At the conclusion of the lesson, students will analyze Anna's cardiac workup and investigate how the function (or dysfunction) of her heart may have played a role in her death.

## **Lesson 4.3 Heart Dysfunction**

The goal of this lesson is for students to explore what happens inside the body when the heart is unable to function properly. Students will investigate the function of cholesterol in the body and research how this lipid can impact health. They will present the information they learn about cholesterol, LDL, and HDL. They will analyze Anna Garcia's cholesterol test results and make recommendations about her cardiac care. Students will then use DNA electrophoresis to separate and analyze DNA fragments to determine if Anna and members of her family have familial hypercholesterolemia. In the final problem of the lesson, students will explore the human heart as a pump and investigate what happens to overall health when factors such as cholesterol plaque impede flow. Students will design and build a simple pump to simulate the heart on the most basic level. Finally, students will design an experiment to simulate the effects of decreased vessel diameter on blood flow rate.

## **Lesson 4.4 Heart Intervention**

The goal of this lesson is for students to explore what happens to the body when blood vessels fail to deliver oxygen to the tissues. Students will investigate medical procedures used to treat blocked blood vessels and prevent events such as heart attack and stroke and build a model to demonstrate one of these techniques. Students will return to both Anna's medical history documents as well as her autopsy report and brainstorm how issues of the heart may have played a role in Anna's final demise. In the final project of the lesson,



students will assess risk of heart disease. They will use an online risk calculator to explore factors that increase or decrease the risk of heart attack or associated coronary disease. They will calculate risk for both Anna Garcia and a patient they have been assigned. As they design a heart disease intervention plan for their assigned patient, students will think about all they have learned in this unit and how lifestyle and the choices we make impact overall health.

## **Unit 5: Infectious Disease**

The goal of Unit 5 is to introduce students to microbiology and infection. Students follow the spread of a simulated epidemic in order to conduct a thorough examination of the agents of disease. Students use clues from their investigation of Anna Garcia's medical history to deduce that she was suffering from a bacterial infection. Through a series of laboratory investigations, students learn the fundamentals of aseptic technique, complete visual identification of bacterial morphology, use the Gram stain to examine bacterial cell structure, and analyze the results of metabolic tests to pinpoint the particular bacterium at the heart of the illness. Students explain the functioning of the human immune system in a visual project and explore how this system is designed to protect against invaders.

### **Infectious Disease Lesson Summary**

Lesson 5.1 .....Infection

### **Lesson 5.1 Infection**

The goal of this lesson is for students to play the role of medical detectives in order to investigate Anna's mystery infection. Ultimately, they will need to identify the exact pathogen responsible for Anna's illness. Students will demonstrate the transmission of an unknown infectious agent from person to person and use deductive reasoning to determine "patient zero." They will investigate a variety of diseases caused by infectious agents and use this information to determine the tests needed to fill in missing pieces from Anna's medical history. They will use aseptic technique to isolate bacterial colonies from four samples and then complete a gross examination of



the colonies from Anna's sample. They will create bacterial smears on microscope slides and perform a Gram stain on three types of bacteria, including the bacteria isolated from Anna's sample. They will look at the stained samples under the microscope, identify the morphology of the bacteria, and determine whether the bacteria are Gram positive or Gram negative. They will use biochemical test results and bacteria identification flowcharts to identify the unknown bacterial species infecting Anna. Finally, students will design a board game or a children's book that showcases how the immune system works to fight infection.

## **Unit 6: Post Mortem**

The goal of Unit 6 is for students to put together all they have learned throughout the course to determine Anna Garcia's cause of death. Students will investigate the structure and function of key human body systems and relate the illnesses in the course to a breakdown in these systems. Students will begin to recognize the coordination and interconnections of the body systems required to maintain homeostasis, a precursor to the theme of the Human Body Systems (HBS) course.

### **Post Mortem Lesson Summary**

Lesson 6.1 .....Analyzing Anna

### **Lesson 6.1 Analyzing Anna**

This lesson is the culminating unit of the course. Students will put together all they have learned throughout the course to determine Anna Garcia's cause of death. Throughout the course they have been compiling an Anna Garcia file with any information they have learned about her and her case. In this final lesson, students will investigate the structure and function of key human body systems and relate all of the ways Anna's various illnesses affected each body system, potentially resulting in her premature death. In the final activity of the course, students will receive one final autopsy report and put together all they know to determine Anna's cause of death. They will think about the interventions or innovations that may have saved Anna that day and reflect on the power of prevention in keeping the body well and safe from harm.