PLTW Biomedical Science
Biomedical Innovation | Course Outline

You are about to embark on detailed missions in science and medicine. Apply all you have learned in the BMS pathway to solve problems, design solutions, and complete each medical mission.

In this capstone course, students apply their knowledge and skills to answer questions or solve problems related to the biomedical sciences. Students design innovative solutions for the health challenges of the 21st century as they work through progressively challenging open-ended problems, addressing topics such as clinical medicine, physiology, biomedical engineering, and public health. They have the opportunity to work on an independent project and may work with a mentor or advisor from a university, hospital, physician's office, or industry. Throughout the course, students are expected to present their work to an adult audience that may include representatives from the local business and healthcare community.

In the Biomedical Innovation course, students will be asked to apply what they have learned in the previous three courses to solve unique problems in science, medicine, and healthcare. Students will work systematically through required problems before completing optional directed problems or independent work. Each problem is staged as a mission – a unique set of tasks the students must work through to achieve their desired objective. Students are presented with each problem in a Mission File – a document that includes a case brief, a list of completion tasks, links to available resources, as well as a reflection section. Working through the missions not only exposes students to current issues in biomedical science, but it also provides skills-based instruction in research and experimentation – tools students will use to design innovative solutions to real-world problems. Students will use what they learn in these missions as they develop and implement their independent project at the end of the year. A teacher may use additional resources in the community – the guidance of other teachers in the school, the advice of scientists or biomedical professionals, or the knowledge presented in scientific literature to help students achieve each goal.

The following is a summary of the units of study that are included in the course for the 2014-2015 academic year. Alignment with NGSS, Common Core, and other standards are available through the PLTW Alignment web-based tool. 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.

BI Unit Summary

Problem 1	Design of an Effective Emergency Room
Problem 2	Exploring Human Physiology
Problem 3	Design of a Medical Innovation
Problem 4	Investigating Environmental Health
Problem 5	Combating a Public Health Issue
Problem 6	Molecular Biology in Action (Optional)
Problem 7	Forensic Autopsy (Optional)
Problem 8	Independent Project (Optional)

Problem 1: Design of an Effective Emergency Room

In this problem students apply their knowledge of emergency medical careers, diagnostic testing and patient evaluation, human body systems, and medical interventions to analyze the workings of an emergency room and discuss inefficiencies that may hinder appropriate clinical care. Student teams will work collaboratively to design a more efficient emergency medicine delivery system. As students work through their designs, they will review research methods, practice effective presentation skills, and learn project management techniques.

Design of an Effective Emergency Room Lesson Summary	
Lesson 1.1	Identity – Human

Lesson 1.1
In this lesson students will focus on biomedical problems related to clinical care. Hospitals and emergency care centers strive to provide quality care to all who enter, but time is of the essence. Timely patient care can make the difference between life and death. The first mission of the course is to design an emergency department that takes efficient patient care to the next level. Using knowledge they have gleaned in the previous courses regarding emergency medical careers, diagnostic testing and patient evaluation, human body systems, and medical interventions, students will analyze the workings of an emergency room, discuss inefficiencies, and work with a team to design a more efficient emergency medicine delivery system. As students work through a solution, they will also review research techniques and proper documentation of sources, practice presentation skills, and discuss project management.

Problem 2: Exploring Human Physiology

In this problem students build upon what they know about the research process in order to design, conduct, and analyze an experimental study. Students will choose a question relating to one or more body systems that they are interested in studying and will work with a team to investigate and answer that question. As students work through the experimental process, they will review and expand what they know about experimental design, collection of data, statistical analysis of data, and the presentation of data.

Exploring Human Physiology Lesson Summary	
Lesson 2.1	Exploring Human Physiology

Lesson 2.1
Whether trying to learn more about the functioning of the human body and the cause of disease, investigating new diagnostic procedures, or testing new or better treatment options, the biomedical sciences rely on scientific research. Scientific research is the systematic method of finding answers to testable questions and making observations for the purpose of learning new facts or testing the application of theories.

In this mission students will learn about the variety of research study designs available and how to set up and conduct valid and reliable studies. Students will investigate the various ways in which data can be manipulated, explore what to look for when evaluating data presented by others, critique scientific data presented in popular media, and compare such data with scientific data presented in scientific journals. Students will learn one process that scientists use to statistically analyze data and then use this process to analyze the results of a scientific investigation. Finally, students will use everything they have learned in order to design, conduct, and analyze an experimental study relating to one or multiple body systems that they are interested in studying.

Problem 3: Design of a Medical Innovation

In this problem students review the diseases and disorders, as well as the corresponding medical interventions they have investigated in the previous courses, and propose a new or better medical device, pharmaceutical, surgical procedure, or genetic intervention. Students will work with a team to build a prototype, model, or schematic of the intervention as well as develop a marketing plan for the product. As students work through this problem, they will review the design process, complete a literature review, and further practice effective presentation skills

Design of a Medical Innovation Lesson Summary	
Lesson 3.1	Design of a Medical Innovation

Lesson 3.1
Whether it is creating a product from scratch or improving a current design, biomedical professionals work to create the specialized products that save lives and make patients safer and more comfortable. In this lesson students will work through a design process to create or improve a medical innovation. Students will investigate the evolution of various biomedical products, brainstorm ideas for a new biomedical product or for a way to improve an existing product, and evaluate solutions of the past and present. Students will explore possible design solutions, select the best approach, and develop a design proposal. Finally, students will showcase their designs with a model, prototype, or schematic and create a marketing plan to pitch their product to potential investors.

Problem 4: Investigating Environmental Health

In this problem students will explore how substances or chemicals in the environment impact human health. Students will investigate a disease cluster in a fictional family and assess the activities of the individuals for environmental risks. Students will test water samples for the presence of contaminants that could be detrimental to human health and use molecular biology techniques to identify specific microorganisms. Students will explore the field of toxicology and design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. Students will then compile a comprehensive environmental health profile and action plan for their local area.

Investigating Environmental Health Lesson Summary	
Lesson 4.1	Investigating Environmental Health

Lesson 4.1
Pollution or contamination in the environment can impact the incidence of disease and affect overall quality of life. In this lesson students will investigate various aspects of environmental health. They will be presented with a fictional family who are all showing gastrointestinal symptoms caused by something in their environment. Through this case students will identify environmental health concerns and toxins and identify potential exposures in their own daily lives. Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which bacterial strain present in the water is making the family sick.

Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. In the final problem, students will compile a comprehensive environmental health profile for their local area. They will use publicly available databases, as well as personal contacts and visits, to uncover possible sources of environmental contamination in the community and to assess risk and level of exposure to people, wildlife, and environmental resources. Students will use their compiled information to design an action plan to increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.

Unit 5: Combating a Public Health Issue

In this problem students draw on information they have learned in the previous courses about public health, epidemiology, and disease diagnosis to work through one of two epidemiology studies. In each study students will analyze data to define the outbreak, generate a hypothesis by diagnosing the patients' symptoms and identifying the disease pathogen, design and analyze an epidemiological study to test the hypothesis, and outline a plan for initiating control and prevention measures. Students will then identify a local, national, or global public health crisis and write a mini-grant proposal, based on the National Institutes of Health grant structure, outlining a plan with intervention strategies. As students work through this problem, they will review evidence analysis, the design process, methodology, and analyze study data to evaluate risk.

Combating a Public Health Issue Lesson Summary

Lesson 5.1 Combating a Public Health Issue

Lesson 5.1

Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. Students will investigate one of two mystery illnesses. They will evaluate patient diagnostic test results to identify the mystery illness, assess evidence to deduce the source of the illness, design and analyze an epidemiological study to test the proposed source, and plan control and prevention efforts to limit future cases of the mystery illness. In this problem students will investigate major health issues in their local area, across the United States, and around the globe. They will evaluate what types of interventions would address these health issues and begin to identify where they feel a comprehensive public health plan will have the greatest impact. The proposed intervention plan could target an infectious disease, a chronic illness, a specific injury or set of injuries, a mental illness, or any other pressing health concern and will focus on the treatment, prevention, research, or education efforts surrounding the chosen health issue. Students will present the plan in the form of a grant proposal.

Problem 6: Molecular Biology in Action (Optional)

In this problem students will complete a multi-step, long-term molecular biology experiment. Students will design and work through a protocol to construct and clone recombinant DNA. They will perform DNA ligation and bacterial transformation, as well as restriction analysis of the completed plasmid. Alternatively, students will work through a more in-depth DNA cloning and sequencing project. This laboratory investigation provides students with the opportunity to isolate plant DNA, perform a ligation and bacterial transformation, purify a plasmid, submit DNA for sequencing, and present all work to GenBank, the NIH genetic sequence database, for publication. As students work through either of these projects, they will learn new laboratory skills, practice laboratory troubleshooting techniques, and review proper protocol for research notebook documentation.

Molecular Biology in Action Lesson Summary	
Lesson 6.1	Molecular Biology in Action

Lesson 6.1

In the previous BMS courses, students have investigated and practiced many of the laboratory techniques of biotechnology and molecular biology. In this problem students have a chance to build upon these skills as they complete one of two long-term projects. Both projects allow students to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation through both transformation and restriction analysis. The second project, described in Problem 6.1.3, asks students to take the process one step further. They will purify the plasmid, sequence the gene of interest, analyze gene data using bioinformatics databases, and submit final work to GenBank, the NIH genetic sequence database, for publication.

Before beginning either wet lab portion of the problem, students will review what they have learned about restriction enzymes. They will complete preliminary logic puzzles to explore the process of ligation and demonstrate how digestion with restriction enzymes, and subsequent gel electrophoresis of the digestion results, can identify specific ligation products. As students work through either laboratory project, they will learn new skills, practice laboratory troubleshooting techniques, and review proper protocol for research notebook documentation.

Problem 7: Forensic Autopsy (Optional)

In this problem students will work as medical experts to work through mysterious death cases. First, as forensic pathologists, students will examine a fetal pig using the same protocol as a human autopsy. Second, students will draw on information they have learned in the previous courses about human body systems to design a fictional death case. Students will showcase the clues left behind in the body and tell the story of how the person died through medical documents, including an autopsy report and medical history forms. Students will finally be tasked with solving another group's proposed case.

Forensic Autopsy Lesson Summary	
Lesson 7.1	Forensic Autopsy

Lesson 7.1
In this lesson students will assume the role of a forensic pathologist to perform an autopsy on a fetal pig, an animal whose anatomy, both internal and external, is very similar to human anatomy. They will examine the fetal pig and note any abnormalities using the same protocol as a human autopsy, including examination of the tissues, organs, systems, and body fluids. Student will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing. Student groups will then exchange scenarios and be tasked with solving each other's mysteries.

Problem 8: Independent Project (Optional)

In this problem students will work independently to determine an area of interest in the biomedical sciences and work on a long-term open-ended problem. Students will use skills learned in the previous courses as well as the previous problems to help them complete their project. Student work will include completing a literature review, writing and carrying out the methodology for their project, analyzing the results, making adjustments as needed, and finally presenting the results of their work to an adult audience. Students may work with mentors or advisors from a university, hospital, physician's office, or industry partner to help guide them as they complete their work.

Independent Project Lesson Summary	
Lesson 8.1	Independent Project

Lesson 8.1
This lesson provides students the opportunity to complete an independent project of their choice. Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
Each project will result in the creation of a product. The choice of project will determine the product. For example, if a student chooses to do a series of experiments, the product could be a laboratory report or a research poster. A student who completes an internship may make a multimedia presentation of the experience. A community event might be the product of a student who wants to inform people about healthy living habits or about a specific illness. Just as the choice of the project is up to you and the student, so is the choice of the product.

Students will review the mission reflections they wrote for the previous lessons, brainstorm topics, and do background research about a topic they choose. They will use their research to write a formal proposal for their project. These will be submitted to you for approval. You and the student will agree on intermediate milestones and products that will be submitted to you. This will allow you to monitor the student's progress on the project. Upon completion of the project, the student will submit a completed product, a written report, a portfolio, and present an oral report to a professional audience.