PLTW Biomedical Science
Medical Interventions | Course Outline

Follow the fictitious Smith family as you learn about the prevention, diagnosis, and treatment of disease.

Play the role of biomedical professionals to analyze case information and diagnose and treat your patients. Investigate the medical interventions of the past and present, and begin to brainstorm the innovations of the future.

Medical Interventions (MI) allows students to investigate the variety of interventions involved in the prevention, diagnosis, and treatment of disease as they follow the lives of a fictitious family. A "How-To" manual for maintaining overall health and homeostasis in the body, the course will explore how to prevent and fight infection, how to screen and evaluate the code in our DNA, how to prevent, diagnose, and treat cancer, and how to prevail when the organs of the body begin to fail. Through these scenarios students will be exposed to the wide range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics. Each family case scenario will introduce multiple types of interventions, reinforce concepts learned in the previous two courses, and present new content. Interventions may range from simple diagnostic tests to treatment of complex diseases and disorders. These interventions will be showcased across the generations of the family and will provide a look at the past, present, and future of biomedical science. Lifestyle choices and preventive measures are emphasized throughout the course as well as the important role that scientific thinking and engineering design play in the development of interventions of the future.

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 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.

MI Unit Summary

Unit 1 How to Fight Infection (25%)
Unit 2 How to Screen What is in Your Genes (15%)
Unit 3 How to Conquer Cancer (30%)
Unit 4 How to Prevail When Organs Fail (30%)

Unit 1: How to Fight Infection

In this unit students are introduced to Sue Smith, the eighteen-year-old daughter of Mr. and Mrs. Smith. Sue is a college freshman who is presenting symptoms of an unknown infectious disease which students eventually identify as bacterial meningitis. Sue survives the infection but is left with hearing impairment. Through this case students will explore the diagnostic process used to identify an unknown infection, the use of antibiotics as a treatment, how bacteria develop antibiotic resistance, how hearing impairment is assessed and treated, and how vaccinations are developed and used to prevent infection.

How to Fight Infection Lesson Summary

Lesson 1.1	The Mystery Infection
Lesson 1.2	Antibiotic Treatment
Lesson 1.3	The Aftermath – Hearing Loss
Lesson 1.4	Vaccination

Lesson 1.1 The Mystery Infection

The goal of this lesson is to expose students to interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. Sue Smith, a freshman, thinks she just has a cold, but further investigation will reveal something far more serious. Students will use various techniques and technologies to diagnose Sue and determine the source of the disease on campus. They will analyze clues found in the history and physical of each possible patient, identify pathogens present in body fluids through DNA sequence analysis, and test for the infectious agent using the antibody-based Enzyme-linked Immunosorbant Assay (ELISA). Students will be introduced to the field of bioinformatics as they explore genetic databases to identify known gene sequences. At the conclusion of the investigation, students will outline a plan to stop a potential outbreak on campus and discuss interventions such as antibiotic therapy and vaccination, two topics to be explored in greater detail in the subsequent lessons.

Lesson 1.2 Antibiotic Treatment

In this lesson students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. They suggest an antibiotic treatment for Sue Smith, as she was diagnosed with a bacterial infection in the previous lesson. Finally, students look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria.

Lesson 1.3 The Aftermath – Hearing Loss

The goal of this lesson is to introduce students to the auditory system. Students will investigate the physics of sound, learn how hearing works, and conduct a variety of hearing assessments. Students will be assigned a patient with a specific type of hearing loss. Using the assigned patient case study, students will explore how damage to the outer, middle, and/or inner ear results in hearing loss. Students will learn how to interpret audiograms and match up their patient case study with the corresponding audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. Finally, students will investigate the science behind cochlear implants and debate the use of this medical intervention.

Lesson 1.4 Vaccination

The goal of this lesson is for students to explore infectious disease prevention and the development of vaccinations. Students will discuss the impact vaccination has had on public health over the years and interpret how vaccines have altered disease trends. Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. Finally, students will explore the career field of epidemiology. Working as epidemiologists, they will brainstorm steps and questions needed to deal with a potential outbreak, analyze data to gather evidence, design epidemiologic studies, and design and implement prevention and treatment strategies.

Unit 2: How to Screen What is in Your Genes

In this unit students are introduced to Mr. and Mrs. Smith, Sue's parents. Mr. and Mrs. Smith are very excited to find out they are expecting a new baby. Because the couple is in their early 40s, the doctor has suggested genetic screening and testing. Through this case students will explore how to screen and evaluate the code in our DNA, the value of good prenatal care, and the future of genetic technology.

The goal of this lesson is for students to examine the available types of genetic testing and screening and discuss ethical implications of these tests. Assuming the role of genetic counselors, students will analyze a patient case concerning issues of genetic testing and provide appropriate recommendations. Next, students will explore molecular techniques necessary to complete a genetic test. They will use the tools of molecular biology to extract their own DNA, amplify a part of the gene for bitter-tasting ability, identify their own gene sequence by restriction digest, and view their resultant genotype using gel electrophoresis. Students then have a chance to test their own phenotype and see how well this genotype predicts their own ability. Finally, students will investigate the interventions that exist to help protect and monitor a growing fetus.

How to Screen What is in Your Genes Lesson Summary

Lesson 2.1	Genetic Testing and Screening
Lesson 2.2	Our Genetic Future
Lesson 2.1	Genetic Testing and Screening

Lesson 2.2 Our Genetic Future
The goal for this lesson is for students to examine how the study of genetics will alter the way doctors and scientists treat disease and the way humans reproduce. Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future.

Unit 3: How to Conquer Cancer

In this unit students are introduced to Mike Smith, the sixteen-year-old son of Mr. and Mrs. Smith. Mike is diagnosed with osteosarcoma, a type of bone cancer that often affects teenagers. Mike's treatments put him into remission; however, in order to remove all of the cancerous tissue, he had to have most of his arm amputated. Mike now needs a prosthesis. Through this case students will explore the diagnostic process used to determine the presence of cancerous cells, the risk factors and prevention of cancer, rehabilitation after disease or injury, and the design process for new medications, prosthetics, and nanotechnology.

How to Conquer Cancer Lesson Summary

Lesson 3.1	Detecting Cancer
Lesson 3.2	Reducing Cancer Risk
Lesson 3.3	Treating Cancer
Lesson 3.4	Building a Better Cancer Treatment

Lesson 3.1 Detecting Cancer

In this lesson students will be introduced to Mike Smith, the sixteen year old son in the Smith family. For the last couple of months, Mike has been experiencing pain in his upper arm that may be indicative of cancer. Through the exploration of Mike's case, students will explore techniques used to diagnose Mike's particular cancer, including diagnostic imaging and examination of cancerous tissue. Students will look at the physiology of cancer and investigate the genes involved with cancer. Students will examine the technology that is being used to give researchers a better understanding of the differences in gene expression in both cancer cells and normal cells. Students learn ways that this technology is being used to potentially develop personalized medicine for treating cancer.

Lesson 3.2 Reducing Cancer Risk

The goal of this lesson is for students to look at some of the risk factors associated with cancer by exploring the various situations which cause changes to our DNA. In particular, students will investigate mutations caused by UV light, mutations that are inherited, as well as mutations caused by viruses. Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. Throughout the lesson students will look at lifestyle choices that can reduce the chances that a person will develop particular types of cancer.

Lesson 3.3 Treating Cancer

The goal of this lesson is for students to follow Mike Smith as he progresses through treatment for his osteosarcoma. Students will learn about the treatments available for cancer patients, as well as the therapies available to help patients cope with the pain associated with treatment. This lesson begins with an introduction to chemotherapy and radiation therapy. Next students investigate biofeedback therapy. They will use data acquisition software to monitor their body's reaction to stress and test methods to reduce their response level. Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery.

Lesson 3.4 Building a Better Cancer Treatment

The goal of this lesson is for students to explore the future of cancer treatment. Students will begin this lesson with an investigation into how one drug can cause varied effects in similar patients and learn about personalized medicine, also known as pharmacogenetics. Students will then investigate the set-up of clinical trials and consider the ethics governing clinical trials. Students will study the nanoscale and the possible application of nanotechnology

in medicine. Finally, students will research the variety of nanotechnologies currently being developed for the diagnosis and treatment of cancer. They will use everything they have learned in this unit to design their own nanotechnology-based cancer treatment and design a clinical trial to test the safety and efficacy of their designed treatment.

Unit 4: How to Prevail When Organs Fail

In this unit students are introduced to Mrs. Jones, the forty-four-year-old sister of Mrs. Smith. Mrs. Jones has been struggling with Type 1 Diabetes for twenty years. Over the years, Mrs. Jones did not take good care of herself or properly control her diabetes. She eventually began using an insulin pump and changed her lifestyle to regulate her blood sugar levels, but the damage had already been done. Mrs. Jones is now dealing with end stage renal failure and needs a kidney transplant. Through this case students will explore protein production, blood sugar regulation, dialysis, organ donation and transplantation, and non-invasive surgery techniques. In addition students will create a bionic human.

The goal of this lesson is for students to investigate the biomanufacturing of human proteins used for medical interventions. They will first use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. Without insulin produced by the biomanufacturing process explored in this lesson, she would have died long ago. As the unit progresses, students will research and design other medical interventions that will help Diana in her battle with diabetes and renal failure.

How to Prevail When Organs Fail Lesson Summary

Lesson 4.1	Manufacturing Human Proteins
Lesson 4.2	Organ Failure
Lesson 4.3	Transplant
Lesson 4.4	Building a Better Body
Lesson 4.1	Manufacturing Human Proteins

Lesson 4.2 Organ Failure
The goal of this lesson is for students to use problem solving and critical thinking skills to solve Diana Jones' medical mystery. Students will investigate Diana's symptoms, suggest further diagnostic tests, and use information they find to piece together the clues provided to make a diagnosis and suggest the best treatment option.

Lesson 4.3 Transplant
In Lesson 4.2 students diagnosed Diana Jones with End Stage Renal Disease. In this lesson students will follow Diana as she goes through the transplant process. Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. Students conclude the lesson by investigating the similarities and differences between kidney transplants and heart transplants.

Lesson 4.4 Building a Better Body
The goal of this lesson is for students to investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the perspective of different stakeholders arguing over whether or not further research for these interventions should be banned. In the final activities, students will have the chance to reflect on everything they have explored in this course. They will think about how science is changing the ability of humans to survive in the face of illness and injury and use what they learned during the course to design their own version of a super human. As they review the Smith family tree, students will reflect on the role medical interventions play in preventing, diagnosing, and treating disease. Finally, students will consider their own career aspirations.