Course Name : Project Lead the Way-Medical Interventions

Course Overview
In PLTW Medical Interventions (MI), students follow the life of a fictitious family as they investigate how to prevent, diagnose, and treat disease. Students explore how to detect and fight infection; screen and evaluate the code in human DNA; evaluate cancer treatment options; and prevail when the organs of the body begin to fail. Through real-world cases, students are exposed to a range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics.

Course Materials/Resources/Technology
1. PLTW Online Curriculum
2. PLTW Online store for purchasing materials

UNIT 1: How to Fight Infection

Duration of Unit: 40 Days

Description of Unit: In the Medical Interventions course, students will investigate the variety of interventions involved in the prevention, diagnosis, and treatment of disease as they follow the lives of a fictitious family. As students experience the health issues and medical decisions faced by members of the family, they will be exposed to the wide range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, rehabilitation, and diagnostics. Each family case scenario will introduce multiple types of interventions and will reinforce concepts learned in the previous two courses, as well as present new content. Interventions may range from simple diagnostic tests to treatment for complex diseases and disorders. Students will track information about this family on a large family tree. This tree will contain information about medical history as well as an inventory of all of the medical interventions encountered by each person. Information will be added to the tree throughout the course and the final product used as a visual reminder of the vast array of interventions that help keep us well.

Essential Questions and/or Enduring Understandings:
- What is a medical intervention?
- What are the main categories of interventions that function to maintain human health?
- How do scientists gather evidence during the potential outbreak of an infectious disease?
- What is bioinformatics?

- How can DNA sequences be used to identify disease pathogens?
- What is an antibody?
- How do antibodies identify and inactivate antigens?
- How can the ELISA assay be used to detect disease?
- Why is it important for doctors to know the concentration of disease antigen present in a patient's system?
- What steps do scientists take to diagnose, treat, and prevent future spread of a disease outbreak?
- How do antibiotics work to fight bacterial infections?
- What methods do bacteria use to share antibiotic resistant genes?
- What actions are humans taking that are contributing to bacteria becoming resistant to commonly used antibiotics?
- How do frequency and amplitude affect how humans interpret sound?
- What causes different types of hearing loss?
- How is hearing loss diagnosed?
- What interventions are available for patients with hearing loss?
- What are the bioethical concerns related to the use of cochlear implant technology?
- What is vaccination?
- How does a vaccine activate the body's immune system?
- How has vaccination impacted disease trends in our country?
- What methods are used to produce vaccines in the laboratory?
- What is recombinant DNA technology?
- What are the molecular tools used to assemble recombinant DNA?
- How can recombinant DNA and bacterial cells be used to produce vaccines?
- How can engineered plasmids be inserted into bacterial cells?
- What is epidemiology?
- How can epidemiologists assist with the detection, prevention, and treatment of both chronic and infectious disease?

Academic Vocabulary:

- Antibody
- Antigen
- Bioinformatics
- Concentration
- ELISA (Enzyme-linked Immunosorbant Assay)
- Enzyme
- Genome
- Medical Intervention
- Outbreak
- Pathogen

- Primer
- Serial dilution
- Solute
- Solution
- Solvent
- Substrate
- Antibiotic
- Antibiotic Resistance
- Conjugation
- Nucleoid
- Plasmid
- Transduction
- Transformation
- Audiogram
- Cochlear Implant
- Conductive Hearing Loss
- Hearing Aid
- Inner Ear
- Middle Ear
- Outer Ear
- Sensorineural Hearing Loss
- Sound
- Case-control study
- Cohort study
- DNA ligase
- Epidemic
- Epidemiology
- Herd Immunity
- Inoculation
- Plasmid
- Recombinant DNA
- Restriction Enzyme
- Vaccination
- Vaccine

ESSENTIAL Standards	**Learning Targets**

Students will conduct a BLAST search to match and analyze a DNA sequence.	
Students will conduct an ELISA experiment to determine the presence of bacteria in simulated cerebral spinal fluid.	1. Explanation of serial dilution and ELISA procedure. 2. Analyzing patient samples to qualitatively and quantitatively assess antigen/antibody concentration. 3. Calculating serial dilutions and resulting concentrations.
Students will conduct an experiment to learn about the mechanisms of DNA exchange in bacteria that can lead to antibiotic resistance and construct a 3D model to explain the that lead to bacteria antibiotic resistance.	1. List and define antimicrobial resistance and gene transfer mechanisms. 2. Summarize the process of genetic transfer illustrated in the Activity 1.2.3 experiment. 3. Summarize the information about all of the mechanisms of antibiotic resistance discussed in Activity 1.2.3 including key terms (e.g. Plasmid, Pilus, Transformation, “Naked” DNA, Transduction, Bacteriophage).
Students will examine the impact of properly taking antibiotics on bacteria resistance.	1. Students define antibiotic resistance. 2. Students explain the importance of completing a course of antibiotics to minimize the creation of antibiotic resistant bacteria. 3. Students analyze data to explain the development of antibiotic resistant bacteria.
Students will conduct a Rinne and Speech-in-Noise Hearing Assessment and match hearing case studies with audiograms.	1. Students explain sound waves using frequency and amplitude and identify key structures of the ear. 2. Students define, explain, and implement different types of hearing tests (e.g. Rinne, Speech-in-Noise, and pure tone). 3. Students analyze audiograms to identify potential hearing losses of an individual and possible medical interventions.
Students will complete an activity on the process of recombinant technology.	1. Students define vaccines, vaccinations, and active immunity. 2. Students identify and discuss different types of vaccines and their development (e.g. live attenuated v. DNA) 3. Students utilize DNA recombinant technology to develop a plasmid vaccine.

NICE TO KNOW Standards	Learning Targets

Common Formative and Summative Assessments
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UNIT 2: How to Screen What's in Your Genes
Duration of Unit: 21 Days
Description of Unit: In this lesson students will examine the available types of genetic testing and screening and discuss ethical implications of these tests. Students will focus on prenatal testing, newborn testing, and carrier screening; however, the use of genetic testing to screen for disease risk will also be addressed. Students will explore genetic risk for chronic diseases such as cancer in more detail in Unit 3. In this lesson, students will examine how the study of genetics will alter the way doctors and scientists treat disease, as well as the way humans reproduce. Students will learn about traditional gene therapy and genome editing. Both are potentially life-saving treatments for many debilitating genetic disorders. Vectors, DNA delivery systems, and nucleases can be used to repair and replace faulty genes with functional copies. By reading articles from opposing viewpoints, students will debate the safety of this practice and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research.
Essential Questions and/or Enduring Understandings: ● What is genetic testing? ● What are the duties of a genetic counselor?

- What is the goal of PCR?
- What are the steps of the PCR process?
- What is the relationship between phenotype and genotype?
- What are SNPs?
- How can restriction enzymes and electrophoresis be used to identify SNPs and determine genotype?
- What medical interventions and lifestyle modifications can help a pregnant woman have a healthy pregnancy?
- What can amniocentesis and chorionic villus sampling tell a couple about their developing fetus?
- How can genetic diseases be cured if scientists could replace faulty genes?
- What vectors can be used to transfer DNA to human cells?
- How might gene therapy open the door to genetic enhancement?
- What medical interventions are available for couples who would like to choose the gender of their child?
- Should parents be able to design their children?
- What is the difference between reproductive cloning and therapeutic cloning?
- What are some of the ethical dilemmas surrounding current and future reproductive technology?

Academic Vocabulary:

- Amniocentesis
- Anneal
- Carrier screening
- Chorionic villus sampling (CVS)
- Denaturation
- Gene
- Genetic counseling
- Genetic testing
- Genome
- Genotype
- Karyotype
- Newborn screening
- Phenotype
- Polymerase chain reaction (PCR)
- Preimplantation Genetic Diagnosis (PGD)
- Primer
- Restriction enzyme
- Single nucleotide polymorphism (SNP)
- Supernatant
- Taq polymerase

- Thermal cycler
- Ultrasonography
- Cloning
- Gene therapy
- In Vitro Fertilization
- Preimplantation Genetic Diagnosis (PGD)
- Sex selection
- Vector

ESSENTIAL Standards	Learning Targets
Students will conduct an experiment using PCR and electrophoresis.	
Students will create a lab protocol and flowchart to conduct the experiment and conduct an experiment to test for the presence for the TAS2R38.	1. Define polymerase chain reaction and single nucleotide polymorphisms. 2. Explain the process of testing for single nucleotide polymorphisms. 3. Identify restriction enzyme cut locations and interpret DNA gel electrophoresis for specific genes. Use genetic information from a gel to determine the genotype of an individual.
Students will complete a simulation on gene therapy.	1. Define gene therapy and describe the general process and goals. 2. Identify good candidates for gene therapy, identify possible viral vectors for treatment, and discuss advantages and disadvantages to viral vectors. 3. Explain how CRISPR-Cas9 works for gene editing and discuss its possible role in future genetic therapy.
NICE TO KNOW Standards	**Learning Targets**

Common Formative and Summative Assessments

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Unit 3: How to Conquer Cancer

Duration of Unit: 52 Days

Description of Unit:
In this lesson students will be introduced to Mike Smith, the 16-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 diagnostic 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 between gene expression in cancer cells versus healthy cells. Students learn ways that this technology is being used to potentially develop personalized medicine for treating cancer.

In this lesson, students will look at some of the risk factors associated with cancer by exploring the various situations that cause changes to our DNA that potentially lead to cancer. In particular, students will investigate mutations caused by UV light and 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, using UV sensitive yeast cells, perform marker analysis on mock DNA samples 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.

Next, students investigate biofeedback therapy, a technique in which people are trained to improve their health or manage pain by learning to control certain internal bodily processes that normally occur involuntarily, such as heart rate, blood pressure, muscle tension, and skin temperature. Students learn that Mike's tumor has spread to the nerves and blood vessels surrounding the original bone tumor, and he will have to have his arm amputated to prevent further tumor growth. Through this scenario, students will explore prosthetic limb technologies as well as the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery.

In this lesson, students will 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 (research studies that investigate how a new medicine or treatment works in human beings), determine if they would be willing to participate in a clinical trial, as well as look at the history behind the ethics governing clinical trials.

Essential Questions and/or Enduring Understandings:

- What fundamental characteristics do all cancers have in common?
- In what ways are diagnostic imaging technologies used to diagnose and treat disorders?
- What do DNA microarrays measure?
- How is DNA microarray technology used to determine the differences in gene expression between different tissue samples?
- How are the similarities of gene expression patterns between different individuals calculated?
- In what ways do different risk factors increase the chance that a person will develop cancer?
- How can lifestyle changes reduce the risk for developing cancer?
- How can molecular tests be used to detect inherited genetic mutations associated with certain cancers?
- How can viruses lead to cancer?
- What is the importance of routine cancer screenings?
- What can a cancer patient receiving chemotherapy and/or radiation therapy expect during treatment?
- How is biofeedback therapy used to help patients improve their health or manage pain?
- In what ways do artificial limbs allow patients who have suffered from the loss of a limb regain lost function?
- How do advances in technology allow for the development of artificial limbs that look and move like actual human limbs?
- How do physical and occupational therapists help patients with disabilities or patients recovering from surgery or injury?
- Questions
- Why do some drugs affect individuals in different ways?
- How can information in our genes affect how our bodies interact with certain medications?
- How are clinical trials set up to ensure all data collected is valid and that all human subjects are treated ethically?
- How might Nanomedicine change the future of medicine?

Academic Vocabulary:

- Apoptosis

- Biopsy
- Bone Scan
- Cancer
- Cell Cycle
- Computed Tomography Scan (CT or CAT Scan)
- Diagnostic Imaging
- DNA Microarray
- Magnetic Resonance Imaging (MRI)
- Oncogene
- Osteosarcoma
- Proto-oncogene
- Radiology
- Risk Factor
- Tumor Suppressor Gene
- X-ray
- Allele
- BRCA
- Cryosurgery
- Familial Cancer
- Genetic Marker
- Hereditary Cancer
- Marker Analysis
- Microsatellite (also known as Short Tandem Repeats-STRs)
- Melanoma
- Model System
- Screening
- Sporadic Cancer
- Virologist
- Biofeedback
- Chemotherapy
- Metastasis
- Myoelectric
- Occupational Therapy
- Physical Therapy
- Prosthesis
- Radiation Therapy
- Clinical Trial

- Controlled Study
- Double Blind Study
- Nanomedicine
- Open Study
- Pharmacogenetics
- Placebo
- Single Blind Study
- SNP

ESSENTIAL Standards	Learning Targets
Students will use microscopy to compare normal and cancerous cells and use simulations to learn about the role of genes in cancer development.	1. Students define cancer and compare normal cell division to cellular division in cancer cells. 2. Students can identify cancer cells via microscopy and define the physical characteristics of cancer cells. 3. Students diagram and describe the role of oncogenes, proto-oncogenes, and tumor suppressor genes in the prevention and formation of cancer. Furthermore, students can summarize metastasis of cancer.
Students will complete a virtual microarray analysis.	1. Define the purpose of DNA microarray. 2. Summarize the process of DNA microarray analysis. 3. Analyze a DNA microarray for gene expression in cancer cells.
Students will research the causes and treatment of skin cancer and conduct an experiment on mutant yeast to study the impact of UV exposure.	1. Students define the three most common types of skin cancer (basal, squamous, and melanoma) and how to identify an abnormal mole (ABCDE). 2. Students describe variables to UV radiation exposure and preventive measures for mitigating the effects of UV radiation on the skin. 3. Students design, conduct, and report on the effects of UV radiation prevention via experimental investigation. In addition, students use this experimental data to design a new medical invention to prevent skin cancer.
Students will research the genetic factors that lead to breast cancer and analyze the gel electrophoresis results without conducting the experiment.	1. Students define sporadic, familial, and hereditary cancers. 2. Students explain the role of BRCA1 and BRCA2 in the development of ovarian and breast cancer and what factors put one at risk for mutation of these genes. 3. Students can create a standard curve plot to identify molecular size of DNA fragments, thus, identifying BRCA1 and BRCA2 mutations.

Students will learn about the use of biofeedback therapy for disease treatment, record the body's response to stress and use the data to return to homeostasis, and design an experiment to study the impact of one relaxation technique.	1. Students define biofeedback and record the body's physiological response to external stimuli using probes. 2. Students research different cancer treatments and biofeedback techniques and define the process and desired outcome of each. In addition, they design an experiment and collect data to assess the effectiveness of one technique. 3. Students complete a lab report that includes research and data about a chosen biofeedback technique. Furthermore, experimental results are used to predict the effectiveness/validity of the technique for different situations.
Students will analyze the DNA sequences of four patients with acute lymphoblastic leukemia and research the impact of single nucleotide polymorphisms (SNPs).	1. Define precision medicine and pharmacogenetics. 2. Summarize how SNP profiles and haplotypes are used to identify the effectiveness of drug treatments. 3. Analyze DNA sequences to identify haplotypes and prescribe a course of chemotherapy treatment from the results.
NICE TO KNOW Standards	**Learning Targets**

Common Formative and Summative Assessments
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Unit 4: How to Prevail When Organs Fail
Duration of Unit: 33 Days

Description of Unit:
In this lesson, students learn how to produce and purify a protein in a laboratory setting in order to understand how human insulin is produced to treat diabetics. Instead of creating insulin, students use the process of bacterial transformation to manufacture a green fluorescent protein (GFP) that is easily visible and can be traced in the laboratory. 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. Since the bacteria now contain a new gene, the cells can produce a new protein, and therefore exhibit a new trait. In this experiment, the bacteria cells will glow a fluorescent green under UV light.

In this lesson students will work in teams to solve Diana's medical mystery, in the same way they diagnosed a mystery endocrine disorder in HBS. 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.

In the last lesson, 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 have to determine who will donate a 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. Finally, students will conclude the lesson by investigating the similarities and differences between kidney transplants and heart transplants.

Essential Questions and/or Enduring Understandings:

- What role does insulin play in diabetes?
- How has the diagnosis and treatment for diabetes changed in the last 200 years?
- How can bacterial plasmids be used to produce proteins such as insulin?
- What is bacterial transformation?
- How can you gauge the success of a transformation experiment?
- How does amino acid structure relate to the overall shape of a protein?
- What is chromatography?
- How can chromatography be used to separate proteins?
- How can electrophoresis be used to check the purity of a protein sample?
- What is SDS-PAGE?
- How does protein electrophoresis differ from DNA electrophoresis?
- What biomedical professionals are involved in all stages of producing and manufacturing a protein product?
- How does a cover letter differ from a resume?
- What is End Stage Renal Disease (ESRD)?
- How is ESRD diagnosed?
- What are the treatment options or medical interventions for patients with ESRD?

- How does dialysis work?
- What (or who) decides who should receive a donated organ?
- How are organ donors and recipient matched?
- What general surgical techniques are necessary for a live donor kidney transplant?
- What are the roles of the various members of the surgical transplant team?
- How does a heart transplant compare to a kidney transplant?

Academic Vocabulary:

- Amino Acid
- Ampicillin
- Chromatography
- Column chromatography
- Gel Electrophoresis
- Genetic engineering
- Hydrophilic
- Hydrophobic
- Insulin
- Plasmid
- Polyacrylamide
- Recombinant DNA
- Transformation
- Transformation Efficiency
- Dialysis
- End Stage Renal Disease
- Hemodialysis
- Kidney Transplant
- Peritoneal Dialysis
- Allocation Policies
- Anesthesia
- Antibody
- Antigen
- Crossmatch
- Haplotype
- Histocompatibility
- Human Leukocyte Antigen (HLA)
- Laparoscope

- Laparoscopy
- Major Histocompatibility Complex (MHC)
- National Organ Transplant Act (NOTA)
- Nephrectomy
- Organ Procurement and Transplantation Network (OPTN)
- Organ Procurement Organization
- Panel Reactive Antibody (PRA)
- Suture
- Tissue Typing (also known as HLA Typing)
- Trocar

ESSENTIAL Standards	Learning Targets
Students will conduct an experiment to transform bacteria to insert foreign genes.	
Students will conduct an chromatography experiment to purify the samples from A4.1.2.	
Students will conduct a SDS-page experiment and build a standard curve to determine the protein's molecular weight.	
Students will analyze the compatible blood types and HLA antigens for transplantation.	

NICE TO KNOW Standards	Learning Targets
Common Formative and Summative Assessments	
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