Medical Interventions Course Description

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. 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 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 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 scientific thinking and engineering design play in the development of interventions of the future.
Medical Interventions Detailed Outline

Unit One: How to Fight Infection
Time Days (45 Days)

Lesson 1.1: The Mystery Infection (17 Days)
Concepts Addressed in Lesson:

1. Medical interventions are measures to improve health or alter the course of an illness and can be used to prevent, diagnose, and treat disease.
2. Bioinformatics, the collection, classification, storage, and analysis of biochemical and biological information using computers, can be used to identify disease pathogens.
3. Diagnostic tests for infectious diseases can provide qualitative results, indicating the presence or absence of disease, as well as quantitative results, indicating the concentration of the infectious agent or of an antibody produced in response to the disease agent.
4. Antibody-based diagnostic tests, such as the ELISA assay, utilize fundamentals of human immune response to detect the presence of disease.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- List medical interventions to create a classroom display.
- Group common medical interventions into categories.
- Maintain case notes of an outbreak investigation.
- Create a graphic organizer displaying connections between individuals in a disease outbreak.
- Use publically available molecular databases to search for DNA sequences and identify pathogens.
- Build a model or draw a diagram that illustrates how ELISA can be used to detect disease.
- Compute serial dilutions and calculate resultant concentrations.
- Perform ELISA testing to determine the concentration of infectious bacteria in simulated body fluids and identify infected patients.
- Write a report summarizing the multi-step process followed to investigate an outbreak of bacterial meningitis.
Lesson 1.2: Antibiotic Treatment (9 Days)
Concepts Addressed in Lesson:

1. Antibiotics disrupt the pathways that bacteria use to survive.
2. Bacterial cells use multiple pathways to gain resistance to antibiotics.
3. Overuse and misuse of antibiotics will promote the selection of resistant bacteria.

Performance Objectives Addressed in Lesson:
*It is expected that students will:*

- Draw and label a diagram of a bacterial cell.
- Research the method of action for different classes of antibiotics.
- Use proper laboratory techniques to “mate” a streptomycin resistant strain of E. coli with an ampicillin resistant strain of E. coli.
- Design and construct a 3-D model that demonstrates one of the pathways through which bacterial cells transfer genes.
- Use a model to simulate the effects of antibiotics on the population of bacteria during an infection.

Lesson 1.3: The Aftermath: Hearing Loss (10 Days)
Concepts Addressed in Lesson:

1. Sound waves have two important properties: frequency (which the ear interprets as pitch) and amplitude (which the ear interprets as loudness).
2. Problems with one or more structures within the ear cause various types of hearing loss.
3. Hearing loss can be evaluated with several, simple hearing tests.
4. There are a variety of interventions available to help people with hearing loss.
5. There are bioethical concerns related to the use of cochlear implant technology.

Performance Objectives Addressed in Lesson:
*It is expected that students will:*

- Create a 3-D model of the structures of the ear.
- Give a short presentation to describe the type of hearing loss experienced by a patient.
- Demonstrate hearing loss on the model of the ear.
- Perform several simple hearing tests.
- Trace the pathway of sound.
- Match up audiograms with their corresponding patients with hearing loss.
- Recommend the most appropriate type of intervention for a patient with hearing loss.
- Write a letter from the opposing perspectives of an adult deaf person expressing his or her reasons for choosing to get a cochlear implant versus an adult deaf person expressing his or her reasons for choosing not to get a cochlear implant.

Lesson 1.4: Vaccination (9 Days)

Concepts Addressed in Lesson:

1. Vaccines are medical interventions that activate the immune system to recognize a disease antigen and produce antibodies necessary to defend the body.
2. Many diseases have been eradicated by large-scale vaccination campaigns.
3. Vaccines can be produced in the laboratory by various methods, including recombinant DNA techniques.
4. Plasmids can be employed as an important tool in genetic engineering and can serve as vectors, vehicles for the movement of genetic information.
5. Epidemiologists are dedicated medical professionals at the heart of the public health field who monitor the health of human populations, search for patterns in the development of both infectious and chronic illnesses assist in outbreak investigations, and design disease treatment and prevention strategies.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Interview people from different generations about their vaccination history and organize findings in a graphic organizer.
- Design a user-friendly vaccination schedule for the parents of a newborn.
- Produce a concept map outlining the laboratory processes used to generate vaccines.
- Engineer a paper plasmid to include the genetic code necessary to produce a vaccine.
- Assume the role of an epidemiologist and complete four tasks to showcase their skills as a professional.

Unit 2: How to Screen What Is In Your Genes
Time Days (23 Days)

Lesson 2.1: Genetic Testing and Screening (16 Days)

Concepts Addressed in Lesson:
1. Genetic testing is the use of molecular methods to determine if someone has a genetic disorder, will develop one, or is a carrier of a genetic illness and involves sampling a person’s DNA and examining the chromosomes or genes for abnormalities.

2. Genetic counseling can help a family understand the risks of having a child with a genetic disorder, the medical facts about an already diagnosed condition, and other information necessary for a person or a couple to make decisions suitable to their cultural, religious and moral beliefs.

3. The polymerase chain reaction (PCR) is a laboratory procedure that produces multiple copies of a specific DNA sequence.

4. Single base pair changes called single nucleotide polymorphisms (SNPs) can be identified through genetic testing and often correlate to specific diseases or traits.

5. Proper prenatal care and monitoring of the fetus are vital to maternal and child health during a pregnancy.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Analyze a genetic counseling case file and provide written and oral feedback to a patient or family.
- Amplify a segment of DNA in the laboratory using PCR.
- Use laboratory techniques such as DNA extraction, PCR, and restriction analysis to identify single base pair differences in DNA.
- Test their ability to taste the chemical PTC and relate this trait to laboratory genetic testing results.
- Create a Venn diagram to compare the process of amniocentesis and chorionic villus sampling.
- Analyze prenatal screening results.
- Write a diary entry that describes proper prenatal care and the medical interventions that function to monitor a pregnancy.

**Lesson 2.2: Our Genetic Future (7 Days)**

**Concepts Addressed in Lesson:**

1. Gene therapy is a type of disease treatment in which faulty genes are replaced by functional copies.

2. Various vectors, including viruses, can be used to transfer DNA into human cells.

3. Both sperm sorting and embryo selection by preimplantation genetic diagnosis (PDG) provide parents the option to select the gender of a child.

4. Advances in reproductive technology open many moral, ethical, and scientific debates.
Performance Objectives Addressed in Lesson:

*It is expected that students will:*

- Construct a graphic organizer comparing and contrasting potential gene therapy vectors.
- Read and summarize current news articles debating the overall safety and value of gene therapy as a treatment option for genetic disorders.
- Write a policy statement governing future gene therapy research.
- Complete a survey of their personal feelings regarding reproductive options of the future.

Unit Three: How to Conquer Cancer

Time Days (58 Days)

**Lesson 3.1: Detecting Cancer** (15 Days)

**Concepts Addressed in Lesson:**

1. Cancer is a term used for more than 100 different diseases in which cell regulation genes are mutated causing the cells to reproduce out of control.
2. X-rays, CT scans, and MRI scans are used to create pictures of the inside of the body to diagnose and treat many disorders.
3. DNA microarrays measure the amount of mRNA for genes that is present in a cell sample.
4. Scientists use DNA microarray technology to determine the differences in gene expression between different tissue samples.
5. Scientists calculate the similarities of gene expression patterns between different individuals using statistical analysis.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Display information about cancer case studies on graphic organizers.
- Create a concept map that describes the different uses for various diagnostic imaging technologies.
- Compare normal cells and cancer cells.
- Perform a simulated DNA microarray to analyze the gene expression patterns of two patients.
- Use statistical analysis to determine the similarity between gene expression patterns of three patients.

**Lesson 3.2: Reducing Cancer Risk** (17 Days)

**Concepts Addressed in Lesson:**
1. Behavioral, biological, environmental, and genetic risk factors increase the chance that a person will develop cancer.

2. The risk for developing many cancers can be reduced with life-style changes.

3. Molecular diagnostic tests, such as marker analysis, can be used to detect inherited genetic mutations associated with certain cancers and can be used to predict risk for developing those cancers.

4. Viruses insert their DNA or RNA into a host cell, causing the host cell’s genes to mutate which can sometimes cause the cell to become cancerous.

5. Routine cancer screenings can prevent certain types of cancer or can increase the chance that cancer is detected at an early stage when treatment is more effective.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Read an article about a potential risk factor that interests them and share it with the class.
- Complete a skin cancer risk questionnaire and evaluate which risks are in their control.
- Use proper laboratory techniques to design and conduct an experiment to test the effectiveness of various sunscreens or types of cloth against UV light using UV sensitive yeast cells.
- Perform marker analysis to determine the presence of a genetic mutation associated with breast cancer.
- Create a mock interview with a virologist either working to develop a new vaccine or drug for a virus associated with cancer.
- Create a timeline of cancer screenings they should do throughout their life using Inspiration® software.

Lesson 3.3: Treating Cancer (12 Days)
Concepts Addressed in Lesson:

1. Chemotherapy and radiation therapy are cancer treatments that work to destroy cancer cells by stopping or slowing their growth; both treatments can cause negative side effects to the patient.

2. Biofeedback therapy is a technique in which patients 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, respiration rate, and skin temperature.

3. Artificial limbs are built to allow patients who have suffered from the loss of a limb to regain lost function.
4. Advances in technology are allowing the development of artificial limbs that look and move more like actual human limbs.

5. Physical and occupational therapists work to help patients with disabilities or patients recovering from surgery or injury, restore function, improve mobility, relieve pain, and improve the ability to perform the tasks necessary to lead an independent and productive life.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Write journal entries or a blog describing the experiences of teenagers undergoing cancer treatments.
- Design and create a simple model of an arm that is able to pick-up an empty Styrofoam cup.
- Create an outline of an article about the history and future of prosthetic limbs.
- Complete a laboratory investigation using data acquisition software and probes to explore biofeedback therapy.
- Design an experiment to test the effect of relaxation techniques on their heart rate, respiration rate, and skin temperature.
- Design and present a comprehensive rehabilitation plan for an assigned patient.

Lesson 3.4: Building a Better Cancer Treatment (14 Days)

Concepts Addressed in Lesson:

1. All drugs do not act the same way for all individuals.
2. SNPs can cause changes in enzymes that metabolize certain drugs in the body.
3. The field of pharmacogenetics investigates how genetic variations correlate with responses to specific medication and strives to develop medical treatments tailored to the individual.
4. Clinical trials are regulated by strict guidelines that ensure data collected is valid and human subjects are treated ethically.
5. Nanomedicine shows great promise, particularly for cancer research, in the hope that medical interventions can be developed at the cellular and molecular scale to diagnose and treat disease.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Complete an alignment to arrange DNA sequences side-by-side to locate any base pair differences between different individuals.
- Use patients’ SNP profiles to predict how they will respond to particular medicines.
- Research and present cases of human abuse that lead to the regulations governing clinical trials.
- Determine how many cuts are necessary to cut a 10 cm x 1 cm strip of paper in half before the paper is approximately ten nanometers long.
- Summarize an article pertaining to the application of nanotechnology in medicine.
- Develop and present a clinical trial proposal to test the safety and efficacy of a nanotechnology-based cancer treatment for an assigned patient.

Unit Four: How to Prevail When Organs Fail
Time Days (49 Days)

Lesson 4.1: Manufacturing Human Proteins (20 Days)

Concepts Addressed in Lesson:

1. The methods used to diagnose and treat diabetes have changed dramatically over the last 200 years, including the use of insulin.
2. Recombinant DNA technology allows scientists to custom-design bacteria that can produce a variety of important protein products, including insulin.
3. Plasmids, rings of DNA containing genes of interest, can be inserted into bacteria cells via the process of bacterial transformation.
4. Chromatography is a technique used to separate components of a mixture and can be used to separate proteins based on the properties of their side chains.
5. Electrophoresis can be used to separate proteins in a mixture and determine the purity of a sample.
6. Numerous biomedical professionals assist with the production, distribution, and marketing of a new pharmaceutical or bioengineered product.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Create a timeline using Inspiration software chronicling the methods used to diagnose and treat diabetes from the 1800s through today.
- Insert plasmid DNA into bacterial cells in the laboratory and observe how this genetic information relates to new traits of the bacteria.
- Calculate transformation efficiency to determine the success of a laboratory experiment.
- Create a 3-D model of a protein that demonstrates how amino acids interact.
• Isolate a protein based on its chemical properties using column chromatography.
• Set up and run protein gel electrophoresis to test the purity of a protein sample.
• Graph electrophoresis results to determine the molecular weight of an unknown protein.
• Produce a flow chart or graphic organizer that outlines the entire process of protein production and purification.
• Write a cover letter for a biomedical professional looking for a job in the field of protein production or biomanufacturing.

Lesson 4.2: Organ Failure (3 Days)
Concepts Addressed in Lesson:

1. End stage renal failure is diagnosed when a patient loses 85 to 90 percent of his/her normal kidney function.
2. When the kidneys are not functioning properly, they will not filter adequately and harmful wastes products such as urea, creatinine and blood urea nitrogen build up in the blood stream and the body will make fewer red blood cells because of the lack of the hormone erythropoietin.
3. Patients with End Stage Renal Disease have three medical options for treatment, including hemodialysis, peritoneal dialysis and kidney transplant.
4. Dialysis is an artificial process that removes waste products and excess water from the blood when the kidneys can no longer function.

Performance Objectives Addressed in Lesson:
It is expected that students will:
• Create an evidence board to document the symptoms of a patient.
• Describe what diagnostic tests need to be run to determine the cause of a patient’s mystery symptoms.
• Research the interventions available for patients with ESRD.
• Write a one-page description of which treatment they would recommend for a patient with ESRD.

Lesson 4.3: Transplant (15 Days)
Concepts Addressed in Lesson:

1. Deciding who receives donated organs is not always a clear-cut issue and involves many difficult decisions guided by federal policies.
2. For the best chance of a successful organ transplant, the donor’s and recipient’s tissue types need to match as closely as possible.
3. The surgical techniques involved in a live donor kidney transplant require skill, dexterity, and eye-hand coordination.

4. The various members of a surgical transplant team work together to make sure the transplant is a success.

5. There are many similarities and differences between a heart transplant and a kidney transplant.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Prepare a computer presentation that details who should receive a donated organ in a given situation.
- Use the information gathered from blood typing tests and HLA typing to determine which of Diana’s relatives is the most appropriate match to be her kidney donor.
- View a laparoscopic nephrectomy and outline the general steps of the surgical procedure.
- Perform general laparoscopic surgical techniques.
- Perform a simulated portion of a kidney transplant surgery.
- Design a heart transplant procedure.
- Complete a Venn diagram to compare and contrast kidney and heart transplants.

**Lesson 4.4: Building a Better Body (11 Days)**

**Concepts Addressed in Lesson:**

1. A variety of tissues and organs can be transplanted from one organism to another.
2. Scientific research is investigating the possibility of replacing damaged organs and tissues using xenotransplantation and tissue engineering.
3. There are benefits and risks of using xenotransplantation and tissue engineering for organ and tissue replacements.
4. Xenotransplantation and tissue engineering pose many ethical questions.
5. Advancing medical knowledge and technology will enable scientists to enhance the human body.
6. Medical interventions prevent, diagnose, and treat disease.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Research a technology being investigated to provide replacement tissues or organs for patients needing a transplant.
• Display information about xenotransplantation or tissue engineering using graphic organizers.
• Formulate and write arguments from the perspective of different stakeholders as to whether or not further research for xenotransplantation and tissue engineering should be banned.
• Design the blueprints for eight replacements and/or enhancements to the human body to create a “super” human.
• Create and present computer presentations that outline the replacements and/or enhancements to create their “super” human.
• Review and write a reflection on all of the medical interventions encountered throughout the course.
• Write a reflection on their career aspirations.