Principles of the Biomedical Sciences
Course Description

This course provides an introduction to the biomedical sciences through exciting hands-on projects and problems. Students investigate the human body systems and various health conditions including heart disease, diabetes, sickle-cell disease, hypercholesterolemia, and infectious diseases. They determine the factors that led to the death of a fictional person, and investigate lifestyle choices and medical treatments that might have prolonged the person’s life. The activities and projects introduce students to human physiology, medicine, research processes and bioinformatics. Key biological concepts including homeostasis, metabolism, inheritance of traits, and defense against disease are embedded in the curriculum. Engineering principles including the design process, feedback loops, and the relationship of structure to function are also incorporated. This course is designed to provide an overview of all the courses in the Biomedical Sciences program and lay the scientific foundation for subsequent courses.
Unit One: Human Body Systems
Time Days (22 days)

**Lesson 1.1: The Mystery** (22 days)

Concepts Addressed in Lesson:

1. The human body is composed of multiple body systems working together to maintain good health.
2. Each human body system is composed of specific organs that interact to complete specialized functions in the body.
3. Determining the cause of death involves the investigation of many aspects of the medical condition of a victim, the internal and external examination of the body, the chemical and microscopic analysis of tissues and body fluids, and may involve many different biomedical professionals.
4. Healthcare professionals are bound by laws and ethical standards to maintain the confidentiality of patients.
5. It is important to evaluate a source of information to insure the information is accurate and unbiased; all sources used for information should be properly cited in presentations and reports.
6. Plagiarism invalidates the work of the person who copied the words, and deprives the original author of credit.

Performance Objectives Addressed in Lesson:

*It is expected that students will:*

- Construct a life-size human body poster, showing the location of major systems in the human body and the organs that comprise them.
- Work as a team member to create a visual and oral presentation, containing pictures and text, to explain the major features and functions of a body system.
- Produce a concept map of a body system.
- Make a concept map showing the interconnections between two body systems.
- Write a summary of the Health Insurance Portability and Accountability Act (HIPAA).
Unit Two: Heart Attack
Time Days (29 days)

Lesson 2.1: What Is a Pump? (2 days)
Concepts Addressed in Lesson:

1. A pump is a machine that moves a fluid from one location to another.
2. There are multiple ways to construct a pump.

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

- Build a pump that successfully moves 150 mL of water from one location to another.

Lesson 2.2: The Structure of the Human Heart (7 days)
Concepts Addressed in Lesson:

1. The human heart is a four-chambered living pump designed to provide the force needed to transport blood through all the tissues of the body.
2. The design of the four-chambered allows the heart to handle both oxygenated blood from the lungs and un-oxygenated blood from the body without mixing the two types of blood.
3. The human heart has different types of tissue which vary in characteristics.
4. A tissue is a group of similar cells designed to carry out a specific function.

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

- Create two dimensional drawings of the human heart labeling all important structures.
- Dissect a sheep’s heart, accurately identifying and describing the function of the specified structures.
- Compare and contrast the characteristics of the different cardiac tissue types.
- Explain how the design of the four-chambered heart allows the heart to pump both oxygenated and un-oxygenated blood without mixing.

Lesson 2.3: The Heart at Work (12 days)
Concepts Addressed in Lesson:
1. Heartbeat is caused by the contraction of cardiac muscle cells resulting in the movement of blood from the heart to the arteries and the rest of the body.

2. Heart rate is the number of heart contractions per unit of time, usually per minute.

3. Heart rate, EKG, and blood pressure measurements are indicators of a person’s medical condition.

4. Internal and external factors affect heart function including heart rate, EKG, and blood pressure.

5. Blood pressure is a measure of the force put on the vascular walls by the blood as it is pushed by the cardiac muscles through the vascular system.

6. The electrical activity of the heart can be measured and recorded by an electrocardiogram (EKG or ECG).

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Make a simple program using LabVIEW software and be able to describe the purpose of the front panel and block diagram.
- Demonstrate the use of technology as an important tool in the Biomedical Sciences by using various Vernier probes and LabVIEW software to collect cardiovascular data.
- Use the Experimental Design Process to create and carry out experiments on blood pressure and heart rate.
- Collect and analyze EKG data.
- Investigate factors that can impact heart rate and blood pressure.

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**Lesson 2.4: Blood – The River of Life** (8 days)

**Concepts Addressed in Lesson:**

1. Blood is liquid connective tissue composed of red cells, white cells and platelets suspended in liquid plasma.

2. Red cells, erythrocytes, contain large amounts of hemoglobin and are essential for transporting oxygen to all body cells.

3. White cells, leukocytes, are responsible for fighting infection.

4. Platelets are cell fragments that are necessary for blood to clot.

5. All blood cells originate in the bone marrow.

6. Blood is the major transport mechanism for substances that must be distributed through the body, including gases, molecules, nutrients, and hormones.

7. The body must continually replenish blood cells.

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

- Identify, sketch, and measure red and white blood cells viewed under a microscope.
- Identify and describe the functions of the major components of human blood.
- Identify and sketch various types of human tissues viewed under a microscope.
- Demonstrate an understanding of the differences between cells, tissues, and organs.
- Use and explain mathematical procedures to estimate size of objects viewed under a microscope.
- Explain the importance of blood to human survival.

Unit Three: Diabetes
Time Days (38 days)

Lesson 3.1: What Is in Our Food? (11 days)

Concepts Addressed in Lesson:

1. Food labels are a useful way to determine which nutrients and what percentages of their daily values are present in a food.
2. Foods are composed of molecules and macromolecules, which in turn are made of atoms.
3. The chemical bonds formed between atoms are sources of energy, and the energy is released when the bonds are broken.
4. Homeostasis depends upon many different chemical reactions.
5. Water is an essential component of human bodies and has unique properties including the ability to dissolve many molecules and compounds.

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

- Analyze food labels for nutritional content.
- Explain the term Dietary Reference Intake and its importance to good nutrition.
- Build and analyze molecular models and diagrams of atoms, molecules and simple compounds.
- Describe the role of chemical bonding in chemical reactions and the transfer of energy.
• Explain the process of calorimetry and how it is used to measure the amount of energy in a food.
• Explain why water is an essential component of human bodies.

**Lesson 3.2: Macromolecules** (7 days)

**Concepts Addressed in Lesson:**

1. Foods contain macromolecules which are broken down and reassembled for use in the human body.
2. Macromolecules are classified into four groups, proteins, carbohydrates, lipids, and nucleic acids, based on their structure.
3. The different classes of macromolecules perform different functions in the body.
4. Macromolecules within the same classification have great variability because of the multiple ways their components can be arranged, and a macromolecule’s function is dependent on the specific arrangement of the components.
5. Chemical indicators can be used to identify specific molecules.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

• Build models of carbohydrates, proteins and lipids.
• Differentiate between the classes of macromolecules in terms of their structures and functions.
• Give examples of different foods that contain each of these types of nutrients.
• Explain the role of indicators in identifying chemical compounds.
• Design a graphic organizer to summarize the results of a food identification activity.

**Lesson 3.3: Molecules Working Together** (3 days)

**Concepts Addressed in Lesson:**

1. Catalysts facilitate chemical reactions by reducing the energy needed for the reaction to occur.
2. Enzymes are usually proteins and act as catalysts in the human body.
3. Enzymes are designed to be highly specific, and the structure of the enzyme’s active site determines structure of the substrate it acts upon.
4. Co-enzymes are needed for some enzymes to function, and many vitamins are co-enzymes.

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

- Create a detailed outline demonstrating an understanding of the structure and function of enzymes.
- Create a concept map illustrating the information in the outline describing the structure and function of enzymes.
- Demonstrate an understanding of both Lock and Key Model and Induced Fit Model of enzyme function by creating and explaining a 3-D model of how enzymes link to substrates.
- Explain the importance of enzymes on maintaining homeostasis in the human body.
- Describe the function of co-enzymes and give examples of co-enzymes found in food.

**Lesson 3.4: The Diabetes Connection** (14 days)

**Concepts Addressed in Lesson:**

1. The human body uses both positive and negative feedback mechanisms to maintain homeostasis.
2. Insulin is the protein that regulates the transfer of glucose into body cells and it is part of a feedback system that maintains the level of glucose in the blood.
3. Diabetes is a disorder caused by insufficient insulin or the inability of the insulin to function properly.
4. Diabetes is a serious health issue in the U.S., with long term impacts on individuals, families, and communities.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Explain how feedback systems are used by the human body to maintain homeostasis.
- Create a 3-D working model that demonstrates the role of insulin in transferring glucose from blood into cells.
- Explain the causes, symptoms, effects, and treatments of both Type I and Type II diabetes.
- Demonstrate an understanding of the dietary requirements and restrictions of people who have diabetes.
- Demonstrate an understanding of the ways in which diabetes can impact one’s daily life.
- Describe behaviors that could help prevent the onset of Type II diabetes.

**Lesson 3.5: Life with Diabetes** (3 days)
Concepts Addressed in Lesson:

1. Diabetes not only affects the individual, but it also impacts the family, friends and associates of the people with this disorder.

2. All carbohydrates, not just simple sugars, must be closely monitored in the daily lives of people with diabetes.

3. The dietary guidelines for individuals who have diabetes are healthy for all people.

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

- Demonstrate an understanding of the lifestyle implications living with diabetes involves.
- Plan a menu that is nutritionally complete and appropriate for a diabetic teenager. (optional)

Unit 4: Sickle Cell Disease
Time Days (35 days)

Lesson 4.1: What Is Sickle Cell Disease? (5 days)
Concepts Addressed in Lesson:

1. Cells need oxygen in order to function properly, and the hemoglobin protein in red blood cells transports oxygen to the cells.

2. People with deformed hemoglobin experience a variety of health issues.

3. Changes to the structure of a protein can change its ability to function properly.

4. The incidence of a particular disease varies between different countries.

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

- Use proper microscope technique to examine and record their observations of normal and sickle red blood cells in their lab journal.

- Use appropriate Internet research techniques to obtain information on the symptoms and complications of the sickle cell trait and anemia.

- Prepare a chart comparing the symptoms and complications of sickle cell trait to sickle cell disease.

- Write a letter to a peer which explains the relationship between the symptoms of anemia and cell energetics.

Lesson 4.2: What Causes Sickle Cell Disease? (8 days)
Concepts Addressed in Lesson:

1. Chromosomes in reproductive cells carry traits through the generations.
2. The expression of a trait through the generations of a family can be visualized using a pedigree.
3. Genetic diseases are passed from parents to children before birth and are not contagious.
4. Changes in the genetic material may cause changes in the traits of an organism.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Use proper laboratory techniques to create chromosome spreads of human HeLa cells.
- Use proper techniques to examine, count, and measure chromosomes from HeLa cells and properly document data.
- Create and analyze pedigree charts to illustrate passage of a trait through at least three generations.
- Calculate the probability of a trait appearing in offspring.

Lesson 4.3: How Do Chromosomes Carry Information? (10 days)

Concepts Addressed in Lesson:

1. Deoxyribonucleic Acid (DNA) is the genetic material for cells and organisms.
2. DNA from all living organisms has the same basic structure—the differences are in the sequences of the nucleotides.
3. Genes, segments of DNA sequence, code for traits.
4. Each chromosome contains numerous genes.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Build a model of the DNA molecule and be able to use appropriate vocabulary to describe its structure.
- Use appropriate laboratory methods to isolate DNA from plant and animal cells.
- Calculate the length of DNA in a cell and properly convert units of nanoscale measurement.

Lesson 4.4: What Is the DNA Code? (7 days)
Concepts Addressed in Lesson:

1. The sequence of nucleotides in DNA determines the sequence of amino acids in a protein.
2. The genetic code is universal.
3. The sequence of amino acids in a protein determines the protein’s 3-dimensional shape.
4. Proteins have multiple structural levels.
5. A protein’s shape is not constant; it changes depending on its environment.

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

- Identify the exons, coding regions, of a gene by comparing the DNA code to the amino acid sequence of the protein.
- Work in teams to build accurate 3-dimensional models of the β-globin protein.
- Design a protein with a specific function by specifying the sequence of nucleotides in the protein’s gene.

Lesson 4.5: Mistakes Happen (5 days) 
Concepts Addressed in Lesson:

1. Chromosomal abnormalities cause multiple, often morbid complications and can be detected by karyotyping.
2. Humans have two copies of each of the 23 different chromosomes.
3. Many diseases are caused by mutations in genes.
4. Changing a single amino acid in a protein can change the properties of a protein and its 3-dimensional shape.

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

- Complete and analyze karyotypes.
- Summarize and present information on syndromes associated with chromosomal abnormalities.
- Assemble models of specified amino acids.
- Create and present PowerPoint presentations on assigned diseases which are caused by a genetic mutation.
Unit 5: Hypercholesterolemia
Time Days (11 days)

Lesson 5.1: Cholesterol (5 days)
Concepts Addressed in Lesson:

1. There are many types of fat or lipid molecules and each has different physical properties and functions in the body.
2. The type of bond between the carbon atoms in a fatty acid determines whether it is saturated or unsaturated with hydrogen atoms.
3. Cholesterol is a lipid and is necessary for the proper functioning of cells and for maintaining a healthy body.
4. Cholesterol is transported in the blood by protein complexes called high density lipoprotein (HDL) and low density lipoprotein (LDL); the measurement of these complexes may indicate a person’s risk for heart disease.

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

- Interpret molecular structure diagrams and correctly construct three dimensional models of stearic acid, oleic acid, linoleic acid, stearidonic acid, and cholesterol.
- Identify a fatty acid as saturated or unsaturated by examining either the structural diagram or a three dimensional model.
- Create a poster or brochure informing other students about HDL and LDL and how these molecules are associated with the risk for heart disease.

Lesson 5.2: Molecular Biological Techniques for Diagnosing Disease (6 days)
Concepts Addressed in Lesson:

1. DNA from numerous sources including blood and saliva can be amplified and analyzed.
2. The Polymerase Chain Reaction (PCR) exponentially increases the number of DNA molecules.
3. Restriction Fragment Length Polymorphism allows for genetic diseases and disorders to be diagnosed by analysis of DNA samples without DNA sequencing.
4. DNA gel electrophoresis separates DNA fragments based on size and is used in Restriction Fragment Length Polymorphism analysis.

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

- Calculate the amplification of DNA during the polymerase chain reaction.
- Create a graph of the amplification rate.
- Use proper laboratory techniques to separate DNA fragments by gel electrophoresis.
- Analyze the results of the gel electrophoresis to correctly diagnose the presence of the familial hypercholesterolemia mutation.

Unit 6: Infectious Diseases
Time Days (17 days)

Lesson 6.1: Bacteria (8 days)

Concepts Addressed in Lesson:
1. Many different types of bacteria exist and only a few cause disease.
2. Bacteria are classified by their reaction to the Gram stain, shape, and metabolism.
3. Antibiotics can be used to treat bacterial infections, but the choice of antibiotic depends on the type of bacteria causing the infection.
4. Many strains of bacteria are developing resistance to antibiotics.

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

- Use proper aseptic technique to sample and transfer bacterial cells to microscope slides.
- Use proper Gram staining and microscope techniques to stain and observe bacteria.
- Perform and analyze a test of antibiotic efficiency using pour plates and antibiotic discs.

Lesson 6.2: Viruses (4 days)

Concepts Addressed in Lesson:
1. Viruses are non-living particles that can infect cells and cause disease.
2. Antibiotics have no effect on viruses and are ineffective treatments for viral diseases.
3. Viruses are very specific and must be able to attach to a cell to be able to infect it.
4. Viruses contain genetic material that can mutate causing a change in the characteristics of the virus, including allowing the virus to attach to new types of cells.
Performance Objectives Addressed in Lesson:
It is expected that students will:

- Use proper research techniques to find information from a variety of sources about the structure of viruses.
- Build an accurate, labeled, and scaled model of a virus particle.
- Produce an accurate and informative PowerPoint presentation about the symptoms, prevalence, prevention, treatment, and the global economic and social impact of an infectious disease caused by a virus.

Lesson 6.3: Public Health Campaign (5 days)
Concepts Addressed in Lesson:
1. Public education can help prevent the spread of disease.
2. Infectious diseases are spread in a wide variety of ways.
3. Basic personal preventive measures including hand washing, surface cleaning, and using tissues can prevent the spread of many diseases.

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

- Design and produce a Public Health Awareness Campaign to inform people about the cause, symptoms, and prevention of an infectious disease.

Unit 7: Medical Interventions
Time Days (13 days)

Lesson 7.1: Medical Interventions (13 days)
Concepts Addressed in Lesson:
1. The field of biomedical sciences includes all sciences related to the prevention of disease and the development of effective treatments.
2. A wide variety of medical interventions are available to prevent and treat disease.
3. Not all patients respond the same way to a medical intervention, and the physician should carefully select the best treatment for each patient.
4. Development of treatment and prevention methods is directly related to engineering principles and technology development.
5. The need for medical interventions drives the development, improvement, and application of technology.
6. The availability of technology drives the development, improvement, and application of medical interventions.
Performance Objectives Addressed in Lesson:
It is expected that students will:

- Analyze the effect of replacing an enzyme on the ability of a living cell (yeast) to complete a chemical reaction.
- Create a product (e.g. game, comic book, or cartoon) that demonstrates the steps or stages in the development, trial, and approval of medical interventions.
- Research, categorize, and summarize the medical interventions that prevent or treat an assigned disease.
- Present and explain the modes of action of the researched medical interventions to the class.

Unit 8: Grant Proposal
Time Days (10 days)

Lesson 8.1: Grant Proposal (10 class days interspersed through last 10 weeks)
Concepts Addressed in Lesson:
1. Medical research is an essential component in the quest to increase longevity and improve quality of life.
2. Medical research has lead to the improved quality of medical care.
3. The necessity for medical research continues to be an important aspect of modern society.
4. Medical research is funded through the grant process.
5. A grant is a detailed proposal describing all aspects of a research project and is used to acquire funds to support research work.

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

- Use consensus to identify a medical condition or disease of interest.
- Identify an aspect of the disease or medical condition in need of research.
- Prepare a detailed grant proposal requesting funds for a research project to impact a specific aspect of the disease or medical condition.
- Use consensus as a decision making strategy on the team.
- Present the grant proposal in the form of an oral presentation.
- Use a rubric to evaluate all team presentations including their own.
- Complete a peer evaluation for team members including a self evaluation.