PLTW Biomedical Science
Human Body Systems | Course Outline

Step inside the human body and explore the systems that help us move, protect us from disease or injury, and facilitate communication within the body and with the outside world.

Solve a medical mystery. Analyze a medical case file and diagnose disease. Design experiments to explore structure and function of the human body.

How do the systems of the body work together to keep us well?

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In the Human Body Systems (HBS) course, students examine the interactions of body systems as they explore identity, communication, power, movement, protection, and homeostasis. Students design experiments, investigate the structures and functions of the human body, and use data acquisition software to monitor body functions such as muscle movement, reflex and voluntary action, and respiration. Exploring science in action, students build organs and tissues on a skeletal manikin, work through interesting real world cases, and often play the role of biomedical professionals to solve medical mysteries.

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.

HBS Unit Summary

Unit 1.....Identity (15%)
Unit 2.....Communication (20%)
Unit 3.....Power (20%)
Unit 4.....Movement (25%)
Unit 5.....Protection (10%)
Unit 6.....Homeostasis (10%)

Unit 1: Identity

The goal of Unit 1 is to engage students in a discussion of what it means to be human. Students investigate the body systems and functions that all humans have in common and then look at differences in tissues, such as bone and muscle, and in molecules, such as DNA, to pinpoint unique identity. Students play the role of forensic anthropologists as they unlock the clues of identity found in bone and use restriction analysis and gel electrophoresis to analyze differences in DNA. Students begin to study histology and build upon their knowledge of human tissue.

In the HBS course, students will be working with an Anatomy in Clay™ two foot skeletal model. Students will work in pairs on an assigned Maniken® model and will use clay to build various organs, tissues, and vessels on the skeletal frame. Over the year each Maniken model will take on a unique identity. Even though students are technically building the same structures on their model, students will notice that the Manikens do not all look the same. Faces will look different. Muscles may be more defined. Blood vessel placement may vary slightly. The Maniken may manifest a disease or illness. The core remains the same, but the specific details will lead to the individual.

Identity Lesson Summary

Lesson 1.1	Identity – Human
Lesson 1.2	Identity – Tissues
Lesson 1.3	Identity – Molecules and Cells

Lesson 1.1 Identity – Human
The goal of this lesson is to set the stage for the Human Body Systems course. It is designed to review important concepts about systems that were presented in Principles of Biomedical Science (PBS). The basic processes of the body unite us as humans, but tiny differences in our appearance, our tissues, and our cells make us truly unique. These differences influence our physical appearance, our personality, our ability to deal with external stressors, and our overall health and susceptibility to disease. Students will begin to explore the way in which human body systems interact to maintain homeostasis as they examine amazing facts about the body. In this lesson students will be introduced to the Anatomy in Clay™ Maniken® model and use his/her body to demonstrate the meaning of various directional and regional terms. As in PBS, students will be given opportunities to explore various careers in the biomedical sciences, play the role of specific biomedical professionals, and document their experience in a career journal.

Lesson 1.2 Identity – Tissues
The goal of this lesson is to introduce students to the main classification of human tissue. Students will research basic information about all four tissue types and use this information to create a graphic organizer. They will use a microscope to view some of the tissue types that contribute to identity, and they will begin to compare the structure and function of these tissues. Students will view more slides and investigate the other tissue types further in later lessons. Students will then play the role of forensic anthropologists to examine skeletal remains and analyze bones to determine as much as possible about the person's gender, race, age, and height. They will use what they have learned about human skeletal structure to take measurements and analyze their findings to provide a preliminary identification of the deceased. Finally, students will use theoretical equations to predict their own height from the length of their bones. Students will then explore how scientists design these equations by using class data to generate an equation for a line.

Lesson 1.3 Identity – Molecules
The goal of this lesson is for students to examine the role that cells and molecules such as DNA and proteins play in human identity. Students will return to their study of the skeletal remains presented in Lesson 1.2. Using simulated DNA samples collected from the bones of the skeleton, students will now use molecular techniques to determine identity. Students will run restriction analysis on simulated DNA samples from the skeleton and from missing persons who match the physical description provided by the bone analysis. Students will run gel electrophoresis to compare the resulting restriction fragment length polymorphisms (RFLPs) and identity the missing person. To wrap up the unit, students will explore how biometrics can be used to secure and verify identity. Students will apply their knowledge to design a biometrics plan for a particular client.

Unit 2: Communication

The goal of Unit 2 is for students to investigate modes of communication within the human body as well as the ways the human body communicates with the outside world. Students map the function of key regions of the brain and explore how the body detects, processes, and responds to internal and external stimuli. Students investigate the roles of electrical and chemical signals in communication and response in the human body. They explore the ways in which hormones and the endocrine system control body function in order to solve a medical mystery. Students compare response time to reflex and voluntary actions using data acquisition software, and they design experiments to test factors that can impact this response. By investigating the anatomy and physiology of the human eye, students learn how the body receives and interprets stimuli from the outside world.

Communication Lesson Summary

Lesson 2.1	The Brain
Lesson 2.2	Electrical Communication
Lesson 2.3	Chemical Communication
Lesson 2.4	Communication with the Outside World

Lesson 2.1 The Brain
The goal of this lesson is for students to investigate how the brain coordinates communication around the body and integrates the function of many systems to assure the body's continued homeostasis. Students will build the central nervous system on their skeletal model. They will explore the specific functions of each region of the brain by creating a detailed map of both structure and function and by completing an optional sheep brain dissection. Students investigate the particular experiments that were used to map the motor cortex and the language center in the brain. Students will explore how the brain sends and receives electrical signals and how electricity is generated and propagated through human systems.

Lesson 2.2 Electrical Communication
The goal of this lesson is for students to investigate how, through electrical and chemical signals, neurons are able to send messages and control body functions. Students will create models of neurons and use interactive websites to visualize how an electrical impulse can be generated from the movement of ions in a membrane. Students will also be introduced to the role that chemicals, specifically neurotransmitters, play in the movement of electrical signals. Response time for both reflex and voluntary actions will be assessed using data acquisition software. Finally, students will investigate what happens when electrical communication breaks down. Playing the role of neurologists, students will analyze case information, provide a diagnosis, demonstrate the breakdown in communication, and present their findings to their peers.

Lesson 2.3 Chemical Communication
The goal of this lesson is for students to examine how hormones carry signals from one cell to another and regulate many of the body's functions, including growth and development, metabolism and reproduction. Students will investigate the structures of the endocrine system, the mechanisms of hormone action, and the regulatory power of feedback. Students will explore the many glands and hormones of the endocrine system as they investigate a medical mystery. They will work as a team and gather evidence to help diagnose an ailing patient. Along the way students will be asked to compare chemical communication with the system of electrical communication they studied in the last lesson. Students will continue to look at specific hormone pathways throughout the rest of the course and consider how they relate to topics such as water balance and the effect of calcium balance on the regulation of blood pressure. Students will continually show more glands, hormones, and targets on an endocrine system graphic organizer.

Lesson 2.4 Communication with the Outside World
The goal of the lesson is for students to investigate how the body processes signals from the outside world, particularly visual stimuli. Students will examine the structure of an eye by completing an eye dissection. They will investigate the many aspects of visual perception by completing and interpreting results for tests in visual acuity, depth perception, peripheral vision, color vision, accommodation, optical illusions, and afterimages. Students will use an eye model to investigate the function of the lens in the eye. They will use this model to test the power of corrective lenses. Students will describe the tests and procedures that go into a routine eye exam and compare three different career paths in the field of vision.

Unit 3: Power

The goal of Unit 3 is for students to investigate the human body systems that work to obtain, distribute, or process the body's primary resources for energy and power—food, oxygen, and water. Students make a model of the digestive system and design experiments to test the optimal conditions for enzymatic digestion. They explore lung function by diagnosing and treating a patient with breathing problems and use probes and data acquisition software to monitor their own lung function. Students investigate the anatomy and physiology of the urinary system and run simulated urinalysis to identify health conditions and diagnose disease.

Power Lesson Summary

Lesson 3.1	Introduction to Power (Optional)
Lesson 3.2	Food
Lesson 3.3	Oxygen
Lesson 3.4	Water

Lesson 3.1 Introduction to Power (Optional)
The goal of this lesson is to introduce students to the concept of power in the human body through examination of the body's ability to survive in extreme environments. They will explore the resources that fuel life as well as debate how long the body can last when these resources become scarce. Students will discuss how environmental conditions and personal factors impact the body's ability to deal with a fuel shortage. As the unit progresses, students will study the body systems that help create, process, or distribute each of the body's three main resources – food, oxygen, and water.

Lesson 3.2 Food
The goal of this lesson is for students to relate the macromolecules that are processed from food to energy potential. Student teams will design and build models of the human digestive system and model chemical digestion of a specific bite of food as it moves through this model. Students will investigate enzyme-substrate interactions and design experiments to test the optimal conditions for the action of the catalase enzyme. Acting as nutritionists or dieticians, students will analyze diet and explore the concept of metabolism. They will assess a fictional client, analyze diet, and write a client report that compares energy inputs and outputs and analyzes overall health and fitness. Finally, students will directly relate food, particularly glucose, to the production of adenosine triphosphate (ATP). They will explore the structure of ATP and examine how this energy source is used to fuel all of the cellular processes in the body.

Lesson 3.3 Oxygen
The goal of this lesson is for students to investigate respiratory system anatomy and analyze how disease impacts function in this system as well as in other systems of the body. In the first activity, students are introduced to a young woman who is experiencing shortness of breath and wheezing during her normal activities. As they progress through her case and make a diagnosis, students explore the structure of the respiratory system and its connection to the cardiovascular system. Students explore the changes in the respiratory system that lead to a condition such as asthma. The second activity introduces students to the mechanics of breathing and to the use of a spirometer to measure lung capacity. Students will then analyze prescription medications and begin to think about how drugs work in the human body. Students will analyze how each medication prescribed to their patient relates to anatomy and physiology. Students will then play the role of a respiratory therapist to design a plan to help their patient manage her illness.

Lesson 3.4 Water
The goal of this lesson is for students to review the many functions of water in the human body and explore the main human body system that not only conserves water and important ions, but also rids the body of harmful wastes – the urinary system. Students will explore the structure of the kidney by completing a dissection and mapping out the general path of urine formation and excretion. Students will then zoom in on the kidney and explore exactly what takes place in the nephron, the functional unit of the organ. By creating a drawing of nephron action, students will explore the connection between blood and urine and then visualize which substances are reabsorbed by the body and which substances are filtered out of the blood and excreted as urine. Students will then investigate how the body uses hormones to regulate and control the amount of water in the body. Finally, students will unlock the medical clues hidden in urine as they complete urinalysis testing for fictional patients. They will see that changes in urine often signal illness or dysfunction that originates in body systems other than the urinary system.

Unit 4: Movement

In Unit 4 students investigate movement of the human body as well as the movement of substances within the body. By building muscle groups on a skeletal model, students learn how a muscle's structure is directly related to its function and to the actions it can produce. Students design experiments to test the requirements for muscle contraction and create models to show relaxation and contraction of the sarcomere. A study of blood flow illustrates the roles that smooth and cardiac muscles play in the transport of substances around the body. At the end of the unit, students combine information about power and movement to describe how the body fuels and responds to exercise. Playing the role of biomedical professionals in a combined medical practice that caters to athletes, students design a comprehensive training plan for an athlete. The plan includes all aspects of training, from diet and exercise to hydration and injury prevention.

Movement Lesson Summary

Lesson 4.1	Joints and Motion
Lesson 4.2	Muscles
Lesson 4.3	Blood Flow
Lesson 4.4	Energy and Motion – Exercise Physiology

Lesson 4.1 Joints and Motion
The goal of this lesson is for students to understand that although our skeleton is rigid and offers great protection and support, joints allow for flexibility and range of motion. Students will research the types of synovial joints and will then observe the structure and function of a joint by dissecting and manipulating a cow elbow. Students will use a device called a goniometer to measure the range of motion of their own joints. They will interpret schematic diagrams and design a method to measure the angle of specific movements.

Lesson 4.2 Muscles
The goal of this lesson is for students to investigate how muscles work with bones to move the human body. Students will examine the three types of muscle tissue under a microscope and describe key differences in structure and function. Students will follow instructions to build the muscles of the chest on their Maniken® model and then independently build another muscle group on their model. They will begin to relate muscle structure to the exercises we choose to tone and strengthen particular muscle groups. Students will then explore the actual process of muscle contraction as they observe contraction of frog muscle. Students will begin to see the requirements for contraction and will further explore this idea as they create a working model of sarcomere shortening. Students will also use this model to explain the phenomenon of rigor mortis. Finally, students will build nerves on their Maniken® model and see the connection between the nervous system and the muscles they have built.

Lesson 4.3 Blood Flow
The goal of this lesson is for students to explore the movement of substances, particularly blood, to our organs and tissues. Students will review the anatomy and physiology of the heart and explore the structural differences in arteries and veins as they investigate the formation of varicose veins. Students will then add clay arteries and veins to their Maniken® model and observe the interaction of blood vessels with muscles. In the final two activities, students will study pressure in the vessels and in the heart by calculating cardiac output and by relating blood pressure to potential health conditions. In a four-part case study, students will investigate the mysterious leg pain of their patient. Students will have a chance to measure and calculate the Ankle Brachial Index (ABI), interpret results of this test, and model disease and potential medical interventions on their Maniken® model.

Lesson 4.4 Energy and Motion – Exercise Physiology
The goal of the lesson is for students to combine information about power and movement to describe how the body fuels and responds to exercise. Students will examine the energy systems the body uses during stages of intense exercise. By completing a lab activity using data acquisition software and probes, students will investigate the phenomenon of muscle fatigue. They will then design experiments to test how the mind may be able to overcome this fatigue. Finally, students will put together everything they have learned thus far in Human Body Systems to design a training plan for an athlete. Playing the role of a biomedical professional in a combined medical practice that caters to athletes, students will design a plan that considers all aspects of training, from diet and exercise to hydration and injury prevention.

Unit 5: Protection

In this unit students explore ways in which the human body protects itself from injury and disease. Before students investigate specific defense mechanisms and the immune system, they explore the protective functions of skin, bone, and the feeling of pain. Antigen-antibody interactions are introduced as well as the structure of the lymphatic and immune system. Students analyze data from a fictional illness and relate antibody response to the action of specific white blood cells.

Protection Lesson Summary

Lesson 5.1	The Skin
Lesson 5.2	Bones
Lesson 5.3	Lymph and Blood Cells

Lesson 5.1 The Skin

The goal of this lesson is for students to explore ways in which the human body protects itself from injury and disease. Students will build a 3-D model of skin and label key layers of tissue and accessory organs. Students will use their models as well as prepared microscope slides to view the epithelial and connective tissue at the core of human skin. Students will then explore what happens to skin when it is damaged by burns. Given what they know about the composition and function of each layer of the skin, students will be able to discuss how damage to the skin can affect its function as well as the function of other body systems. Through writing fictional diary entries about time in a burn unit, students will investigate career areas related to care and rehabilitation after a burn. Finally, students will debate pain as a protective mechanism.

Lesson 5.2 Bones

The goal of this lesson is for students to investigate the structure of bone and relate this structure to the role that calcified tissue plays in protection of the internal organs and of the body as a whole. Students will observe and dissect a section of a cow long bone and create a detailed drawing of external and internal bone structure. Students will view prepared slides of both compact and spongy bone and compare the structure of each bone type.

Students will further examine the strength of bone by analyzing bone breaks. They will research the many types of bone fractures and work to match X-rays of broken bones to descriptions of each injury. Students will explore the bone's remarkable ability to heal itself as well as the ongoing process of bone remodeling. Students will investigate the relationship between the maintenance of healthy bone, the amount of available calcium in the blood, and the hormones that control this balance.

Lesson 5.3 Lymph and Blood Cells
The goal of this lesson is for students to take a deeper look at the body system that functions to drain and distribute fluid in the body, and to protect the human body against specific invaders – the lymphatic and immune system. Students will investigate how immune cells protect the body while it is under attack and explore how these cells initiate a highly specific response against particular microbes, such as viruses or bacteria, or abnormal cells, such as cancer cells. Students will then be introduced to the idea of antigens and antibodies by completing a simulated blood typing exercise. Working as lab technicians, students will use their knowledge of antigen and antibody interactions to determine the blood type of members of a family. They will use this data to determine potential blood donors for a transfusion. Finally, students investigate the response of white blood cells to invasion by a pathogen. Students will graph data of antibody concentrations at various stages of illness and relate these numbers to a flow chart of what is happening in the immune system.

Unit 6: Homeostasis

This final unit focuses on the connection between all of the human body systems and examines how these systems work together to maintain health and homeostasis. Students explore how the body deals with extreme external environments as well as how the body reacts to and defends against injury and illness. Students begin to discuss and design medical interventions for a fictional case study. The activities in this lesson are an engagement for the subsequent course, entitled Medical Interventions (MI).

Homeostasis Lesson Summary	
Lesson 6.1	Health and Wellness

Lesson 6.1 Health and Wellness
The goal of this lesson is for students to examine how the systems of the body work together to maintain health and homeostasis. Students will reflect on the way in which the body systems work together to provide identity, facilitate communication inside and outside of the body, power movement of substance around the body and of the body as a whole, and protect the body from harm. They will compile information from the graphic organizers they have created all year into organizers that are broken down by function. In this lesson students will have the chance to explore a disease and design a case study for a fictional patient. By building the case from start to finish, they will learn how a disease presents in the body, how it is diagnosed, and how the illness or injury is treated. Students are responsible for showcasing input from various biomedical professionals as well as for showing the physical manifestation of the disease and demonstrating an effective medical intervention on their Maniken® model.