Bone, Muscle and Prosthetic
Unit for Surfaces and Nanotechnology

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Overview
The students at my school need to be motivated to want to learn, so areas of interest that will keep their attention while they learn is essential. Students are very interested in how their bodies develop. They are fascinated by the concept of replacing a body part, such as, an arm or leg. Medical research has been able to develop very realistic looking and functioning limbs. By doing research, activities, and experiments the students will better understand their own development and how medicine was able to construct replacement limbs. The students will be fourth and fifth graders. The unit will be multidisciplinary combining math, writing, reading, and social studies along with science. The unit is designed for 6 weeks with a 45-minute lesson a week.

Rationale:
My students look forward to the variety of activities and experiments that they perform in science class. Our school is located in Southwest Philadelphia, and is a predominately African American student body from families of lower incomes. The necessary reading in the research of subject matter helps the students improve in reading. The calculations achieved with experiments and activities helps the students enhance their math learning. The need to replace a limb can bring concern for a different life style and possible social acceptance that would bring social studies into the unit, as would the history of the development of artificial limbs.

We have tried to replace limbs for hundreds of years using wood and straps…

How the Body Works

Through the centuries, scientists needed to understand the human body, not only to treat, but also to replace limbs. Dissection of cadavers was the means to learning and by the 14th century notes were being completed for study. Inventions such as the microscope (late 17th century) and in 1896 the x-ray machine aided in the learning of the human body. (Abrahams, 6 and 7)

The brain controls the body and has 31 pairs of nerves from the spinal cord to the rest of the body. The sciatic nerve from the sacral plexus forms the sensory and motor supply from the spinal cord down the back of the thigh, divides behind the knee and continues to the heel. (Abrahams, 89 and 90)

The brachial plexus forms the sensory and motor supply from the spinal cord to the upper limbs. There is a pattern of dermatomes within the skin over the body that is the sensory nerve supply. A doctor can test for nerve damage by a pinprick on a dermatome such as in a finger. (Abrahams, 77)

The thyroid gland found in the neck regulates the calcium levels by secretes calcitonin. In children growth is dependent upon the thyroid by its stimulation of metabolism of carbohydrates, proteins and fats. The parathyroid glands secrete parathormone works with calcitonin and vitamin D to control calcium metabolism. (Abrahams, 82-83)

The upper limbs are attached to the axial (central) skeleton by the pectoral girdle. The muscles that involve the arm in the front of the body are: triceps brachii (extends the arm and forearm), latissimus dorsi (broad muscle of the back; powerful muscle of arm extension) and pectoralis major (pulls the arm toward the body). The muscles that involve the arm in the back of the body are: infraspinatus (used in a backhand stroke in tennis), teres major (acts with latissimus dorsi to extend the arm), and supraspinatus (raises arm away from body). (Abrahams, 98-99)

The axilla, or armpit is important to the arm because it contains vessels, nerves and lymphatics connecting to the thorax for the upper arm. Blood and oxygen are carried to the upper arm by the axillary artery. The nerves found in the axilla are part of the network known as the brachial plexus. (Abrahams, 128)

The muscles in the forearm are: pronator teres (moves the lower arm and flexes the elbow), flexor carpi radialis (flexes the wrist and bends it away from the body), flexor carpi ulnaris (flexes the wrist and bends towards the body), flexor digitorum superficialis (flexes the fingers), flexor digitorum profundus (flexes the last joint of the fingers), supinator (turn the palm up), and flexor pollicis longus (flexes the thumb). (Abrahams, 138)

The lower limbs are connected to the spine by the pelvis bones. The pelvis bones permit the weight of the body to be transferred to the legs. (Abrahams, 196)

A thick muscle in the buttock region allows the body to stand. The gluteus maximus is the one of the largest muscles in the body. The main function of this muscle is to straighten the leg, as when the body stands up. The gluteus maximus is used also when the body runs or walks upstairs. (Abrahams, 200)

Large muscles are found in the thigh, which move the hip and the knee. There are three groups one runs in front of the femur another runs behind and the third runs between the inner femur and the pelvis. The muscles in the thigh that produce the foreward motion in walking are: illopsoas, tensor fasciae latae and rectus femoris. The quadriceps femoris is a large muscle in the thigh that permits running, jumping and climbing. (Abrahams, 212)

There are three groups of muscles in the lower leg. The anterior muscles lift the toes, so they do not drag when the foot moves forward. One of these muscles, the gastrocnemius, flexes the knee and foot. The extensor hallucis longus, extends the big toe. The flexor hallucis longus in the posterior of the lower leg and acts to give the big toe its push off during walking and running. Also in the lower leg, is the calcaneal (Achilles) tendon, the largest tendon in the body. (Abrahams, 214-215)

Bones and Muscles

The skeleton system is composed of bone organs plus joints. The human body has an endoskeleton or "hard dried body within". The endoskeleton has two parts the axial skeleton and the appendicular skeleton. The appendicular skeleton consists of the bones in the four limbs including the shoulders and hips. (Layman, 153-155)

The appendicular skeleton is formed by mostly short or long bones. Two sets of flat bones are found in the shoulder girdle, the scapula and the hip girdle, the os coxa. The femur or thighbone does look like a long stick, which has a knob at the end called the head of the femur. Coming near this head are two protrusions one called the greater trochanter enables a person to run because of the muscles attached. We find short bones in the wrist called carpal and tarsal bones in the ankle. There are a total of 126 bones in the appendicular skeleton. (Layman, 157-158)

By using the femur we can learn the parts of a long bone. The main shaft or diaphysis runs through the middle. At either end is a bone cap or epiphysis. The long bone has a thin shell like covering of bone matrix. This white matrix is very hard and full of calcium and under the periosteum. The periosteum is a thin membrane that covers most long bones. Both the periosteum and the matrix have holes that are called nutrient foramina, which sends a nutrient blood vessel to the inner long bone to supply nutrients to the bone tissue. Within the middle of the bone shaft or diaphysis is found the medullary or marrow cavity. There is an endosteum or thin membrane that lines the medullary cavity. (Layman, 159-161)

There are two types of bone marrow: the mainly red-colored blood vessels found in spongy like bone tissue that is used in hematopoiesis and the mainly yellow-colored adipocytes or fat cells found in the medullary or marrow cavity of long bones and is an energy reserve. (Layman, 161-162)

When a bone is broken it can be a simple fracture, when no skin is damaged, but when there is skin damage the fracture becomes a compound fracture. Infection is more likely to occur with a compound fracture. An incomplete fraction is referred to as a greenstick fraction, as it does not break through the bone. If the skin is damaged, a compound greenstick fraction can occur. (Layman, 165-166)

There are three types of joints in the human body two are found in the head and the spine, but the third is found in the limbs. The diarthroses are movable joints that are also called synovial joints. Synovial fluid is found between joints and enables them to move with less friction. (Layman, 168-169)

Arthritis occurs when there is an inflammation of joints, which can be very painful. If the immune system produces autoantibodies, abnormal proteins chemically attack and destroy synovial fluid of some joints. (Layman, 169-170)

The body has about 600 different skeletal muscle organs. The tendons attach muscles onto bones. The muscle has a middle that is full and rounded in shape with each end thinning to where it connects to a tendon. The muscle fascia are the layers of tissue that are contained in a muscle. The epimysium is a fascia that looks milky. Inside the muscle are fascicles that are gathered muscle fibers and covered by fascia. Found within the muscle fibers is an endomysium. Muscle fiber is a cell that can only be seen with a microscope. Muscles are named by several different criteria: 1) number of cep(s) which is where the muscle is attached to a tendon, 2) body location, 3) where attached to the skeleton 4) shape 5) action 6) size 7) direction of muscle fibers and 8) real people or those from myths. (Layman, 176-185)

Bone Development and Structure

Bone has both living tissue and non-living materials. Found in the living tissue are blood vessels, nerves, collagen and living cells. The cells are of two type osteoblasts, which form bone and osteoclasts that remove old bone. Another cell found in bone are called osteocytes, which are osteoblasts that no longer form bone. Instead they exchange metabolically with the blood that flows through the bones. Minerals and salts are the nonliving materials found in bone.
(www.nsbri.org/HumanPhysSpace/focus6ep_development.html, 1)

In addition to the cells in bone there is a matrix of fibers and chemicals. Among the materials are collagen fibers and crystalline salts. These salts are mainly of calcium and phosphate, which form hydroxyapatite crystals. These chemicals give bones strength to endure stretching and compressing.
(www.ncbri.org/HumanPhysSpace/focus6ep_development.html, 1)

The fetus has a skeleton made of cartilage, which has no minerals or salts. Cartilage is replaced with osteoblasts and osteoclasts cells, as the fetus grows and ossification starts. (A baby grows most in the first year of life and by age 2 is about half its adult height. By the age of 12 a child's skeleton will be ossified. Most children grow on average 2-3 inches a year. Most girls stop growing by age 18 and boys by age 20.) (Treays, 24-25) The minerals, salts including calcium taken from the blood are necessary for ossification the formation of bone.
(www.ncbri.org/HumanPhysSpace/focus6ep_development.html, 2 and 3)

Physical activity strengthens long bones, which continue to grow into adolescence. The thickness of bone must be a constant in the body and therefore new bone is made to replace old bone. The body digests the old bone. The process of replacing old bone by new continues until around age 40, then it slows down, as bones start to become more brittle.
(www.ncbri.org/HumanPhysSpace/focus6ep_development.html, 3 and 4)

To develop strong bones, you need good nutrition, exposure to sunlight, hormonal secretions, and physical exercise. Sunlight enables the skin to produce vitamin D. Without vitamin D; calcium would not be absorbed properly. Normal bone growth and development also needs vitamins A and C.
(www.ncbri.org/HumanPhysSpace/focus6ep_development.html, 4)

The growth hormone is somatotropin, secreted by the pituitary gland. This hormone regulates the height of a person. Somatotropin also maintains the normal synthesis of protein in all body cells. Other hormones control the level of blood calcium.
(www.ncbri.org/HumanPhysSpace/focus6ep_development.html, 4)

Growth charts as used by a doctor measure the length/height from age birth to 36 months for both boys and girls. Also measured is the weight, even before birth. The chart shows space to list mother and father's height. Doctor's track this information to assess if the child is developing within normal growth ranges.
(http://pediatrics.about.com/library/growth_charts/nboysbirth.html, 1) and
(http://pediatrics.about.com/library/growth_charts/ngirlsbirth.html, 1)

Doctor's continue to keep records on height and weight of patients until the last visit. But the critical time in development is the first three years. As a doctor monitors a child's growth patterns, he can determine if diet and exercise need to be changed or continued.

Apatite for Bone

"Apatitie is a group of phosphate minerals, usually referring to hydroxylapatite, fluorapatite, and chlorapatite."

"Apatitie is one of the few minerals that are produced and used by biological micro-environmental systems. Apatite has a Mohs Scale hardness of 5. Hydroxylapatite is the major component of tooth enamel. A relatively rare form of apatite containing many carbonate and acid phosphate substitutions is a large component of bone material."
(wikipedia.org/wiki/Apatitie, 1)

Proteins for Muscle

"Proteins are organic compounds made of amino acids arranged in a linear chain and joined together by peptide bonds between the carboxyl and amino groups of adjacent amino acid residues. The sequence of amino acids in a protein is defined by the sequence of a gene, which is encoded in the genetic code. Proteins are essential parts of organisms and participate in every process within cells. Many proteins are enzymes that catalyze biochemical reactions and are vital to metabolism. Proteins also have structural or mechanical functions, such as actin and myosin in muscle and the proteins in the cytoskeleton, which form a system of scaffolding that maintains cell shape."
(wikipedia.org/wiki/Protein, 1)

In 1838, A Swedish chemist Jons Jakob Berzelius was the first to describe proteins. He used the Greek word proteios "primary" for the name. Not until 1926 was the major role of proteins in living organisms fully appreciated, when James B. Sumner showed that the enzyme urease was a protein. Insulin was the first protein to be sequenced, by Frederick Sanger, the Nobel Prize winner in 1958. Also in 1958, the first protein structures to be explained were hemoglobin and myoglobin, by Max Perutz and Sir John Cowdery Kendrew. X-ray diffraction analysis showed the three-dimensional structures of both proteins; Perutz and Kendrew shared the 1962 Nobel Prize in Chemistry. (wikipedia.org/wiki/Protein, 1)

"Antibodies are protein found in the immune system whose main purpose is to bind antigens, or foreign substances in the body, and work to destroy them. (wikipedia.org/wiki/Protein, 7)

"Proteins that serve structural functions are motor proteins such as myosin, kinesin and dynein, which are capable of generating mechanical forces. They generate the forces exerted by contracting muscles." (wikipedia.org/wiki/Protein, 8)

"To study a protein the method of cellular localization is immunoelectron microscopy. This technique also uses an antibody to the protein of interest, along with classical electron microscopy techniques. The sample is prepared for normal electron microscopic examination, then treated with an antibody to the protein of interest that is conjugated to an extremely electro-dense material, usually gold. This allows for the localization of both ultrastructural details as well as the protein of interest. The total complement of proteins present in a cell or cell type is known as its proteome." (wikipedia.org/wiki/Protein, 9)

" Most microorganisms and plants can biosynthesize all 20 standard amino acids, while animals (including humans) must obtain some of the amino acids from the diet. The amino acids that an organism cannot synthesize on its own are referred to as essential amino acids." (wikipedia.org/wiki/Protein, 10)

" In animals, amino acids are obtained through the consumption of foods containing protein. Ingested proteins are broken down through digestion, which typically involves denaturation of the protein through exposure to acid and hydrolysis by enzymes called proteases. Some ingested amino acids are used for protein biosynthesis, while others are converted to glucose through gluconeogenesis, or fed into the citric acid cycle. This use of protein as a fuel is particularly important under starvation conditions as it allows the body's own proteins to be used to support life, particularly those found in muscle. Amino acids are also an important dietary source of nitrogen." (wikipedia.org/wiki/Protein, 11)

The best sources of protein are beef, poultry, eggs, dairy products, nuts, seeds, beans, and lentils. (kidshealth.org/kid/stay_healthy/body/protein.html, 1)

Prosthetics

History is not able to verify the first artificial limb made. However, Herodotus, a Greek historian did record about 500 B.C., the story of a prisoner who cut off his own foot to escape his chains. The man was able to walk on a wooden foot. The oldest artificial limb was discovered in 1858. It was made from copper and wood and could be dated to 300 B.C. (Woods, 39)

In the 1700's artificial arms and legs were made using a leather cup affixed to a wooden peg. The cup covered the stump and leather straps connected the cup to the person's body. These prosthetics were heavy and uncomfortable and could fall off, when the straps became undone. (Woods, 40)

Moveable artificial limbs were invented, in 1580, by Ambroise Pare, a French surgeon. The hand was operated by springs, which could tighten around objects. The leg actually had a moveable knee joint. Suction was used by Dubois Parmelee of New York City, in 1863, to keep artificial limbs in place. (Woods, 40-41)

The injuries during the U.S. Civil War (1861-1865) and World War I (1914-1918) had thousands of soldiers needing artificial limbs. Inventers used stronger and lighter materials to construct prosthetics for the soldiers. (Woods, 41)

Since the mid-1900s, the designs for prosthetics have continued to evolve using very strong plastics, spacecraft type metals, electronics and computers. (Woods, 41)

Myoelectricity, the electricity found inside human muscles, is used in artificial limbs. The science to have limbs controlled by myoelectricity came about in the 1960s. Electrical signals are sent through the person's body via sensors. (Woods, 41-42)

The Utah Arm was developed in 1981. This arm had electrical and mechanical parts that ran on a rechargeable battery. The Rehabilitation Institute of Chicago, in 2003, created an arm controlled by a person's thoughts. The arm uses electrical connections that a person has in our nervous system. (Woods, 42-43)

Today, the medical field that covers prostheses is biomechatronics. It is the blending of mechanical parts with the human muscle, skeleton and nervous systems. The reasons for needed a replacement part are usually: absent at birth, injury, or defective. (wikipedia.org/wiki/Prosthesis, 1)

In the 1980's, a major change in the socket used in leg prosthetics was invented, by John Sabolich. The new socket held the limb in place like a glove, and enabled the person to achieve better movement. (wikipedia.org/wiki/Prosthesis, 2)

A robotic prosthesis uses biosensors that receive signals from the nervous or muscular systems. There is a controller inside the prostheses that processes the information from the biosensors. (wikipedia.org/wiki/Prosthesis, 2)

The construction of a prosthetic foot by Dycor will use "resin transfer infusion and lightweight polypropylene components". Another foot design "the advanced composite epoxy and fiberglass keel can be sanded to conformity." Integrated carbon fiber is used in another foot design. The other materials used are titanium, and urethane-fiberglass in still other designs. One reason for different varieties in the manufacture of a prosthetic foot are the activity level of the patient. (http://www.dycormfg.com/proFeet.html, 1 and 2)

Materials are still being developed and tested. The use of a composite material is commonly thought to be the best. The composite would include reinforcement such as a fiber and a matrix such as a resin. The most often used are nylon, fiberglass and carbon

fibers and polyester, acrylic and epoxy resins.
(http://www.acpoc.org/library/1992_02_062.asp, 1)

Bionics

Dr. Jack E. Steele, of the U.S. Air Force, used the Greek word, bion, which means life or living to explain bionics. Dr. Steele introduced the term on September 13, 1960, at a scientific meeting called by the Air Force at the Wright Patterson Air Force Base in Dayton, Ohio. "He described it as the study of the systems and structures of living animals and plants, and the application of these principals to devising machines and artificial systems for the benefit of humans". (Berger, 5)

The science of bionics has developed so new parts for the human body, such as artificial limbs could be produced. (Berger, 5)

Biologists study the animal and plant systems that give models for developments in the field. Engineers conceive and construct the machines and hardware that make these natural models in synthetic devices. "In the slang of bionics, biologists do the wet work; the engineers do the dry work". (Berger, 5)

Physicians contribute by not only studying the human body, but in preparing parts to be used in or on the body. Mathematicians take the notes formed of the natural systems and put into precise numbers and figures of a scientific model. Other experts in electronics, nuclear energy, chemistry, the science of materials, and many other specialties have added knowledge to the field. (Berger, 5)

There are two hooks in a prosthesis hand. One hook is fixed in place, while the other is connected to a spring mechanism. A cable attaches the hook to the harness, which attaches to the body. A procedure back during World War I actually had steel pins implanted in muscles and cables ran from the pins to the artificial hand. Using the nerve impulse in the muscles enabled the person to just think and move the hand. (Berger, 18)

Since that time artificial limbs have been built that move by nerve impulses from the brain. These are battery operated and with the electricity used are called myoelectric. In one myoelectric arm, three small buttons are placed inside the existing portion of arm. A button is attached to the median nerve, another to the ulna nerve and the third a ground to prevent electrical shocks. Wires to the power pack in side the hollow prosthetic arm attach each of the three buttons. Within the power pack are an amplifier and a motor to control how the hand and fingers move. So, just by thinking a person with a myoelectric arm can tie his shoelaces and pick up tiny objects. In 1975, a myoelectric arm was developed that weighs only 8 pounds and can grip 40 pounds and not get tired. The cost of the myoelectric arm was $40,000 as compared to a regular prosthesis at $1,500 to $2,000. Batteries can be a heavy source of energy. Scientists have worked in fluids and hydraulics, and nuclear energy as a power source for prosthetic limbs. (Berger, 19 to 21)

A bionic implant is more functional then a prostheses, because it acts as well as if not better than the original. The best know bionics today, are the cochlear implant for the deaf, and the artificial heart. Nanotechnologies are sure to further the development of bionics. Robert Freitas has designed an artificial red cell, a respirocyte, which is a nanodevice. (wikipedia.org/wiki/Bionics, 4)

"Nanotechnology is the study of the control of matter on an atomic and molecular scale. Generally nanotechnology deals with structures of the size 100 nanometers or smaller, and involves developing materials or devices within that size". (en.wikipedia.org/wiki/Nanotechnology, 1) With more development of bionics in prosthetics, nanotechnology will continue to research and test applications for improvement. One such area is the use of embedded nanobioelectronics. (en.wikipedia.org/wiki/Nanotechnology, 6)

Biomedical engineering is a field of study that among other devices develops artificial limbs. (en.wikipedia.org/wiki/Biomedical_engineering, 3)

A branch of biomedical engineering is clinical engineering, which actually has the artificial limb in use with a patient. This area will also train technicians and study the progress of a patient using prosthesis. (En.wikipedia.org/wiki/Biomedical_engineering, 5)

Because of soldiers losing limbs in Afghanistan and Iraq, the DARPA (Defense Advanced Research Projects Agency) has joined with DEKA Research and Development Corp. to develop a better prosthetic. Also, in the development of a more human like prosthesis is Oak Ridge National Laboratory (ORNL) and Applied Physics Laboratory (APL) of Johns Hopkins University. A new technology, mesofluidics that would give actuation to prosthetic finger, thumb, wrist, elbow and shoulder joints is being experimented. Part of the technology is powered by a lithiumpolymer battery pack; the pump compresses and displaces the fluid. As pressure builds up, the oil forces the piston to the cylinder's end, causing the elbow or finger joint to bend. (www.nanowerk.com/news/newsid=3914.php, 1)

Transplants

The procedure to attach a donated hand for example has been successful. The problem lies in the medication that the recipient needs to take to prevent rejection. The anti-rejection medication suppresses the immune system, which can lead to infections or cancer. One protocol for trying to solve this problem is to give the patient a drug called Campath, suppressing the immune system. The next step is to inject bone marrow from the donor, and when the Campath wears off the immune system will recognize the new bone marrow and not attack the hand. (Inquirer article, dated April 6, 2009 by Mark Roth)

Objectives:

The students will learn the following:

How their bones and muscles develop

How artificial limbs, prosthetic were developed

How the materials that are used for prosthetics were developed, this will include nanotechnology
How to better take care of their bones and muscles

Students will be doing research on the various aspects of human development, prosthetic (with the materials used) development and recommended care of bones and muscles. The students will discover some of the information themselves via the Internet, books and materials presented by the teacher. The students will do hands on activities/experiments as they learn.

Strategies
Before beginning research the students will brainstorm with the teacher using KWL (what you know, what you want to know, and what you want to learn). Skills of doing research on the Internet and using encyclopedias and other books would be reviewed. The growth and development of the human body is of such interest to students that they will want to see the charts and diagrams that show how they developed and continue to grow. The medical profession and research and products that are now being used to replace a limb will also interest the students and they will want them to discover the various aspects that occur to replace a limb. The students will try to construct an artificial limb and see the challenges that faced early inventors. The study of the products used in the production of a prosthetic will lead to the learning of nanotechnology, which should prove fascinating.

Classroom Activities

Lesson One
Objective: To introduce the unit and have students want to investigate the four main topics; how their bones and muscles develop, how prosthetics were developed, the materials that are now used and how to better care for their bones and muscles.

Activities: Show a brief clip of the actor, who lost both hands in WWII, in the movie The Best Years of Our Lives. Show a brief clip of the Star Wars movie where Luke's artificial hand is being repaired. Prosthetics will be googeled and the videos at the bottom of the page will be viewed to show how far we have come. The class will look at the picture of the mother holding the baby that has electrical connections (Woods, 42). The class will complete the KWL chart that covers the development of their bones and muscles, how prosthetics were developed, including materials and the latest in bionics and the care of their bones and muscles. Vocabulary will be introduced including working definitions. I would want to give the students an example of how the medical profession was able to learn about the human body by dissection. Use pieces of raw chicken to show the periosteum, which is a thin membrane covering most long bones. The periosteum can be seen by running a sharp knife (only the teacher will use) along the bone to see the thin milky membrane peeling off the bone. (Layman, 159)

Lesson Two
Objectives: The students will begin researching how their bones and muscles developed and continue to grow. The students will use the Internet and encyclopedias and other materials supplied by the teacher. The question of flexibility in movement will be discussed. The experiment that they conduct will introduce the concept of materials for prosthetics.

Activities: The students will try an experiment with rulers that can bend without breaking and will bend back to being straight to show elasticity. But they will discover that bending with too much pressure will make it harder for the ruler to return to a straight position causing plasticity. The amount of pressure will be charted along with the angle of the bend.

Lesson Three

Objectives: Students continue to research information on the development and in the materials for prosthetics. Each student will construct a prosthetic using cardboard tubes and bendable plastic for joints. This activity will give them a sense of what a research developer must accomplish. They will also write about their feelings as they tried to complete activities with one hand or one leg.

Activities: The students will try walking on one leg and realize how difficult it is to balance, even with a walking stick. They will also try using only one hand or arm to do an activity such as cutting paper. The student will design and make a list of materials needed to construct their chosen limb. The student can choose from a leg (including knee), an arm (including elbow) a hand (including fingers and wrist), or a foot (including toes and ankle). The teacher will supply materials, except the cardboard tubes, which will be supplied by the students (paper towels).

Lesson Four

Objectives: After the last lesson on constructing a limb from cardboard tubes, the students will now learn about the materials that an engineer could use to design and construct a limb. By examining the tags on their shirts, the students may see polyester as the material, or the teacher will show an example. Polyester resins are used to form fiberglass. Lower leg prostheses incorporating fiberglass/epoxy and carbon fiber/epoxy composite materials have been developed.

Activities: The students will make a list of items that are made from fiberglass such as tent poles, pole vault poles, arrows, bows, and auto bodies. However, since those items would be hard to use in a classroom, Christmas decorations will be used. The class will work in groups and after placing the decorations, such as angel hair, or a sheet of snow in a flat position; they will try to pull them apart. They should discover that pulling along the fiber, doesn't work, they need to pull perpendicular to the fiber, to displace the material. The class will then research what makes the fiberglass so strong and good for use in the manufacture of a prosthetic. The students will investigate using the web site en.wikipedia.org/wiki/Fiberglass and a copy given out by the teacher.

Other activities for more lessons: The classes will try to bend chicken bones and see them break. The students will then put chicken bones in vinegar for two to three days to show the bone able to bend, because the calcium has been dissolved.

The classes will gather height measurements of two year olds to predict future stature. The students will use medical records from family members to check if predictions should hold true.

The class will use charts of the human body to identify bones and muscles that they can feel and see under their skin. They will also play a game of name that bone or muscle such as I am the largest tendon in the body who am I? Achilles

Bibliography

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Woods, Michael and Woods, Mary B., Major Inventions Through History, The History of Medicine, Minneapolis, Twenty-First Century Books, 2006. Pages 39 to 43

En.wikipedia.org/wiki/Apatite page 1

en.wikipedia.org/wiki/Protein pages 1 and 7 to 11

en.wikipedia.org/wiki/Prosthesis pages 1 and 2

en.wikipedia.org/wiki/Bionics page 4

http://www.nsbri.org/HumanPhysSpace/focus6ep_development.html pages 1 to 5

http://kidshealth.org/kid/stay_healthy/body/protein.html page 1

http://en.wikipedia.org/wiki/Biomedical_engineering pages 3 and 5

http://en.wikipedia.org/wiki/Nanotechnology pages 1 and 6

http://www.nanowerk.com/news/newsid=3914.php page 1

http://en.wikipedia.org/wiki/Fiberglass pages1 to 4

Annotated Bibliography for Teachers

Abrahams, Peter, The Atlas of The Human Body, Amber Books Ltd, London, 2002 It would be good for the teacher to have a reference book to show additional pictures and explanations on the subject matter.

Berger, Melvin, Bionics, New York, Franklin Watts, 1978 This book explains the history of bionics in prosthetics over the 20 years that they were originally developed.

Layman, Dale Pierre, Anatomy Demystified, New York, McGraw-Hill, 2004 Use this book as a resource for the human anatomy and to possibly answer questions that the students ask, that are not covered in student books.

En.wikipedia.org/wiki/Prostheis, when you google prosthetics there are two videos to view at the bottom of page, that students will enjoy.

Annotated Bibliography for Students

Macnair, Dr. Patricia, Movers & Shapers Bones, muscles, and joints, Kingfisher, Boston, 2004 Students will enjoy and find the pictures and graphics interesting. The info lab box on every other page will add to the learning experience.

Treays, Rebecca, Understanding Your Muscles & Bones, Usborne, New York, 2004 Contains a wealth of pictures, charts, illustrations and facts that will advance the students understanding.

Woods, Michael and Woods, Mary B., Major Inventions Through History, The History of Medicine, Minneapolis, Twenty-First Century Books, 2006. Students will find the illustrations and pictures interesting with regards to artificial limbs and bionics. The other inventions contained in the book might lead to other lessons.

Resources

Movies
The Best Years of Our Lives, 1946 the story of three returning veterans to their families. One man in the Navy lost both hands in an explosion on a ship. Star Wars, Empire Strikes Back, 1980 Luke is seen getting an artificial hand.

Web sites
www.kidshealth.org/kid/body/muscles_SW.html and
www.kidshealth.org/kid/body/bones_SW.html good for information for the students
http://yucky.kids.discovery.com/flash/body/pg000123.html for muscles and
http://yucky.kids.discovery.com/flash/body/pg000124.html for skeleton both are good especially the side links
www.bbc.co.uk/science/humanbody/body/index.shtml?muscles good game to show body parts and function
www.iofbonehealth.org/patients-public/more-topics/bone-development-in-young-pe…
www.kidshealth.org/kid/stay_healthy/body/protein.html
www.kidshealth.org/kid/htbw/bones.html
www.nsbri.org/HumanPhysSpace/focus6ep_development.html

Appendices

The Philadelphia standards that align with the Pennsylvania State Standards

Fourth Grade:
3.1.4 Unifying Themes

- A. Know that natural and human-made objects are made up of parts
- B. Know models as useful simplifications of objects or processes.
- E. Recognize change in natural and physical systems.

3.2.4 Inquiry and Design

- A. Identify and use the nature of scientific and technological knowledge.
- B. Describe objects in the world using the five senses.

3.4.4 Physical Science, Chemistry and Physics

- C. Observe and describe different types of force and motion.

Fifth Grade:
3.1.7 Unifying Themes

- A. Explain the parts of a simple system and their relationship to each other.

3.2.7 Inquiry and Design

- B. Apply process knowledge to make and interpret observations.