Biomedical Engineering (Crowdsource Content)

STEM.org[1]

[1]Journal of Conceptual and Applied STEM Education

April 10, 2019

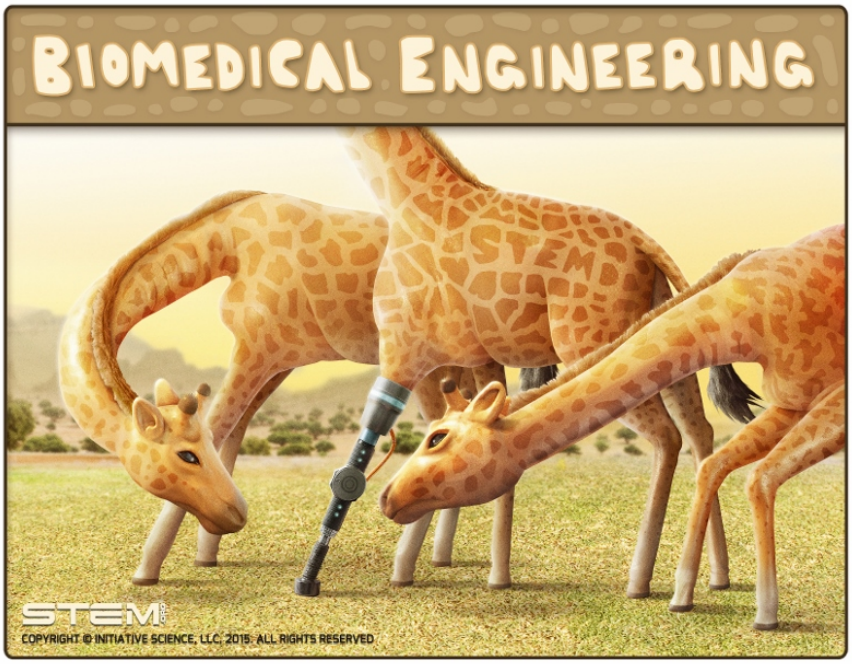

Figure 1: This is a caption

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Figure 3: Biomedical Engineering Proficency Badge

Abstract

Students will begin by exploring the field of biomedical engineering, investigating the various branches to determine what interests them the most and learning directly from a professional who works in the field. To

gain a foundation in medical science, students will gain exposure to osteology, anatomy, and cellular biology by exploring various media and building their own models. Then, students will explore DNA and genetics, genetic engineering and the current debate over GMOs (or genetically modified organisms), and the science of stem cells and their many applications in medicine and science. Students will also explore technology used in the field, by visiting a medical laboratory or medical imaging center, conducting their own research on specific devices and equipment, and developing skills in computation and programming.

Students will focus on specific aspects of the field by learning about the relationship between bionics (the study of natural processes and movements for the purpose of engineering and medical applications) and the development of prosthetics for treatment of missing limbs and organs. Finally, students will complete and share their final presentations on the books they read throughout the semester, relating what they have learned about biomedical engineering to personal interests and real-world applications.

Course Texts and Materials

Book Report Options

- Being Mortal by Atul Gawande
- The Big Fat Surprise: Why Butter, Meat and Cheese Belong in a Healthy Diet by Nina Teicholz
- The Checklist Manifesto by Atul Gawande
- The Cost of Cutting: A Surgeon Reveals the Truth Behind a Multibillion-Dollar Industry
- County: Life, Death and Politics at Chicago's Public Hospital by David Ansell
- The Emperor of All Maladies by Siddhartha Mukherjee
- Living and Dying in Brick City: Stories from the Front Lines of an Inner-City E.R. by Sampson Davis and Lisa Frazier Page
- The Man Who Mistook His Wife for a Hat by Oliver Sacks
- The Man Who Touched His Own Heart by Rob Dunn
- The Optimism Bias by Tali Sharot
- The Tale of the Dueling Neurosurgeons by Sam Kean
- Tasty: The Art and Science of What We Eat by John McQuaid
- Plant Biomechanics: an Engineering Approach to Plant Form and Function by Karl J. Niklas
- Biomimicry: Innovation Inspired by Nature by Janine Benyus

Required Texts, Kits, and Resources

- "Biomedical Engineering." Bureau of Labor Statistics. http://www.bls.gov/ooh/ architecture-and-engineering/biomedical-engineers.htm
- Biomedical Engineering Website (BMES) homepage. http://bmes.org/content.asp? contentid=40
- "Biomedical Engineering." Columbia University. http://bme.columbia.edu/high-school- students
- Light, Douglas B. Cells, Tissues, and Skin . (Human Body: How it Works) http:// amzn.com/1604133708
- Life Size Human X Rays: http://www.hometrainingtools.com/life-size-human-x-rays-set
- Broken Bone X Rays: http://www.hometrainingtools.com/broken-bones-x-rays
- Complete anatomy chart
- Skeletal system chart
- 4D Science Animal Cell Model: http://amzn.com/B003BYKP7U
- 4D Science Plant Cell Model: http://amzn.com/B003BYM7VM
- "Eukaryopolis." Crash Course. Video (11.34) https://youtu.be/cj8dDTHGJBY
- http://www.cellsalive.com/
- http://www.cellsalive.com/cells/3dcell.htm Cell Models
- http://www.cellsalive.com/puzzles/index.htm Cell puzzles

- http://www.cellsalive.com/worksheets/AnimalCellModel.pdf Animal Cell Model worksheet
- "Once Upon a Time: Life — the Cell." Once Upon A Time. Video (11:41) https://youtu.be/ tjFtXXLC2bs
- DNA, Replications and Transcriptions Set. http://amzn.com/B000O8Z7UQ
- DNA Necklace Extraction Kit. http://www.carolina.com/dna-extraction-quantification- kits/dna-necklace-classroom-kit/211138.pr or Genes in a Bottle Kit http://www.bio- rad.com/en-us/product/genes-bottle-kit
- "What is DNA and How Does it Work?" Stated Clearly video (5.23) https://youtu.be/ zwibgNGe4aY
- "The Science of Candy." Exploratorium. Interactive website. https:// www.exploratorium.edu/cooking/candy/sugar.ht
- "Food4Me Science." Interactive website. http://www.food4me.org/about/nutrigenomics
- Nabhan, Gary Paul. Food, Genes, and Culture: Eating Right for your Origins . http:// amzn.com/1610914929
- "List of Organisms by Chromosome Count." https://en.wikipedia.org/wiki/ List_of_organisms_by_chromosome_count
- "Mike's New Car." Monster's Inc Short Film (Disney Studios). Video (3.48) https:// youtu.be/WBkK4rg_w0U .
- "Tiki's Guide to Genetic Engineering." Interactive website. http://tiki.oneworld.net/ genetics/home.html
- "Agriculture's Sustainable Future: Breeding Better Crops." Scientific American. http:// www.scientificamerican.com/a sustainable-future/
- Merino, Noel. Genetic Engineering (Opposing Viewpoints). http://amzn.com/ 0737764252
- "Agriculture's Sustainable Future: Breeding Better Crops." Scientific American. http:// www.scientificamerican.com/a sustainable-future/
- Knoepfler, Paul. Stem Cells: an Insider's Guide . http://amzn.com/9814508802
- "Acid Shock Converts Adult Cells to Stem Cells." http://www.genengnews.com/gen- news-highlights/acid-shock-converts-adult-cells-to-stem-cells/81249434/ , or similar article from journal Nature or other.
- "Bioengineering" game at Centre of the Cell https://www.centreofthecell.org/learn-play/ games/bioengineering/
- Other biomedical games: https://www.centreofthecell.org/learn-play/games/
- Remote Control Machines Kit. National Geographic Store http:// shop.nationalgeographic.com/ngs/product/kids/toys-and-games/all-toys/remote-control- machines-kit?code=SR50002
- Mindflex Game http://amzn.com/B001UEUHCG or Duel Game http://amzn.com/ B004GHNFKK and/or one of the other devices listed in the Scientific American article
- "Sea Turtle Gets New Lease on Life with Prosthetic Flippers. BBC, various other sources available as well. http://www.bbc.com/news/world-asia-21434189
- "Prosthetic Limbs, Controlled by Thought" article and "The Bionic Man" short film. New York Times Video (8.36) http://www.nytimes.com/2015/05/21/technology/a-bionic- approach-to-prosthetics-controlled-by-thought.html?_r=0
- "Trouble Walking? Try Honda's New Exoskeleton Legs." https://youtu.be/6pWvxA4jvbc
- "Six Electronic Devices You Can Control With Your Thoughts." Scientific American. http://www.scientificamerican.com 6-electronic-devices-you-can-control- with-your-thoughts/
- Kaku, Michio. The Future of the Mind. http://amzn.com/0307473341
- Bee Bot app, available on iTunes: https://itunes.apple.com/us/app/bee-bot/id500131639? mt=8
- Daisy the Dinosaur: https://itunes.apple.com/us/app/daisy-the-dinosaur/id490514278? mt=8
- Scratch (free): https://scratch.mit.edu
- Hopscotch: https://www.gethopscotch.com and Tynker: https://www.tynker.com
- Sidewalk chalk
- Codea: http://twolivesleft.com/Codea/

Optional Build Kits and Resources

- Human Body: How it Works series
- Gray's Anatomy Coloring Book: http://www.hometrainingtools.com/grays-anatomy- coloring-book
- "Plant Cells." Crash Course.

- "Tour of the Cell." Bozeman Science. Video (14.16) https://youtu.be/1Z9pqST72is - Punnett square: http://scienceprimer.com/punnett-square-calculator - EPOC Emotiv with software development tools. https://emotiv.com/epoc.php - Kodable School (as supplement): https://www.kodable.com - For more inspiration and resources: http://code.org - "How to Play Hopscotch." http://www.wikihow.com/Play-Hopscotch

Next Generation Science Standards

DNA (deoxyribonucl eic acid)	Transcription is the first step of gene expression, in which a particular segment of DNA is copied into RNA (mRNA) by the enzyme RNA polymerase
RNA transcription	a substance that carries genetic information in the cells of plants and animals
Ribosomes	any of various round or long cellular organelles of most eukaryotes that are found outside the nucleus, produce energy for the cell through cellular respiration, and are rich in fats, proteins, and enzymes
Mitochondria	any of the RNA-rich cytoplasmic granules that are sites of protein synthesis

Please note: This module provides a foundation of qualitative content. Please incorporate quantitative methods, systematic procedures, and mathematics throughout the module.

Lesson 1: Biomedical Engineering: Introduction

Suggested Time: 60 minutes Overview

Students will begin by exploring the field of biomedical engineering, investigating the various branches to determine what interests them the most. Then, they will learn directly from a professional who works in the field.

Vocabulary

- Biomedical engineering
- Biomechanics
- Tissue engineering
- Genetic engineering
- Neural engineering
- Pharmaceutical engineering
- Medical devices
- Medical imaging
- Clinical engineering

Objectives

- Students will learn the definition of biomedical engineering and explore its specializations.

Required Project Materials

- Computer laboratory or individual computers
- Large poster board and markers

Multimedia Resources

- "Biomedical Engineering." Bureau of Labor Statistics. http://www.bls.gov/ooh/ architecture-and-engineering/biomedical-engineers.htm
- Biomedical Engineering Website (BMES) homepage. http://bmes.org/content.asp? contentid=40
- "Biomedical Engineering." Columbia University. http://bme.columbia.edu/high-school- students
- Light, Douglas B. Cells, Tissues, and Skin . (Human Body: How it Works) http:// amzn.com/1604133708

Optional Multimedia Resources

- Human Body: How it Works series

Before the Lesson/ Background Information

- Locate a guest speaker or two in the field. Request that the speaker(s) bring a prop or physical project to engage the students—such as an innovative medical device.

The Lesson

Part 1: Biomedical Engineering (30 mins)

1. Ask students to define biomedical engineering. Respond to ideas and definitions and discuss the main sections of the field using the vocabulary words above.
2. Using the computer lab, students will explore the discipline, beginning with the links on the Dept. of Labor website and BMES. Instruct them to explore what the college program is like at Columbia University, clicking on the "Careers" tab and learning about their summer program for high school students. They can explore other programs and universities as well.
3. Instruct the students to write down main points as they explore the websites.
4. Assign a subdiscipline (e.g., tissue engineering) to each student, or allow them to pick their favorite. Each student will then perform their own research and share a brief summary with the whole class.

5. As a class, brainstorm the skills and knowledge needed to go into biomedical engineering. Write down the ideas on a large poster paper and hang it in class.
6. Instruct the students to write down a few questions for the guest speaker.

Part 2: Guest Speaker (30 mins)*

1. Introduce the guest speaker(s).
2. Reserve at least 15 minutes for the students to ask the speaker questions.

*If you cannot find guest speakers, arrange a suitable field trip. Active engagement with a speaker or interesting site is a great way to boost student interest at the beginning of the course. If this is not possible, have each student select a specific job title to play-act. Have them come up with skits and perform them as examples of how people with different jobs in the field may work together.

Homework:

- Students will select a health or engineering-related book from the list of optional texts (or a text of their choice). They will read the book throughout the semester and turn in a book report at the end of class.
- Assign readings from Cells, Tissues, and Skin.

Lesson 2: Anatomy and Osteology

Suggested Time: 60 minutes

Overview

To gain a foundation in medical science, students will explore osteology and anatomy by building their own anatomical models.

Vocabulary

- Anatomy
- Osteology
- Skeletal system
- Endocrine and muscular system
- Cardiovascular system
- Integumentary system
- Nervous system

Objectives

- Students will gain a basic understanding of osteology and anatomy.

Required Project Materials

- Life Size Human X Rays: http://www.hometrainingtools.com/life-size-human-x-rays-set
- Broken Bone X Rays: http://www.hometrainingtools.com/broken-bones-x-rays
- Complete anatomy chart
- Skeletal system chart
- Tape, glue, scissors
- Various craft items: string, clay, construction paper, felt balls, styrofoam, pipe cleaners, etc.

Multimedia Resources

- None

Optional Multimedia Resources

- Gray's Anatomy Coloring Book: http://www.hometrainingtools.com/grays-anatomy- coloring-book

Before the Lesson/ Background Information

- None

The Lesson

Part 1: Osteology and Anatomy Models (60 mins)

1. Divide the students into five groups, one for each system of the body.
2. Referencing the skeletal system diagram, the skeletal system group should work together to build a complete skeleton using the Xrays. They can tape them to the wall. Using stickies, students will label the different bones.
3. Each of the other groups will build an anatomical model using the craft items, working back and forth with the charts, focusing on their particular system.
4. Next, each group will present to the class on the parts of their system and how it works.
5. Display the various models on the class wall.

Homework:

- Students will work on their reading and book report.
- Assign reading from from Cells, Tissues, and Skin.

Lesson 3-4: Eukaryopolis

Suggested Time: 120 minutes

Overview

Students will explore the parts of the cell, study animal and plant cell models, then create their own model of a specialized cell.

Vocabulary

- Organism
- Single-celled organism
- Multicellular organism
- Cell
- Eukaryotic (animal cell)
- Organelle
- Mitochondria
- Ribosomes
- Cytoplasm
- Endoplasmic Reticulum
- Golgi Apparatus
- Lysosomes
- DNA
- RNA transcription
- Centrosomes
- Nucleus

Objectives

- Students will learn about cells and cell parts.
- Students will learn about the functions of cell parts.
- Students will create their own specialized cell model.
- Students will learn how highly specialized cells work together to create a functional organism.

Required Project Materials

- Microscope
- Leaves or other live organic material
- Soil or other substances containing organic material
- Animal cell samples (e.g., hair)
- Computers or iPads with Internet
- Cell Model Worksheet http://www.cellsalive.com/worksheets/AnimalCellModel.pdf
- Cell Model Diagram (try a Google image search)
- Craft items such as pipe cleaners; construction paper and cardboard; recyclable packing peanuts; fuzzy mini balls; yarn and string
- Tape, scissors, glue, and paints
- 4D Science Animal Cell Model: http://amzn.com/B003BYKP7U
- 4D Science Plant Cell Model: http://amzn.com/B003BYM7VM

Required Multimedia Resources

- "Eukaryopolis." Crash Course. Video (11.34) https://youtu.be/cj8dDTHGJBY
- http://www.cellsalive.com/
- http://www.cellsalive.com/cells/3dcell.htm Cell Models

- http://www.cellsalive.com/puzzles/index.htm Cell puzzles
- http://www.cellsalive.com/worksheets/AnimalCellModel.pdf Animal Cell Model worksheet
- "Once Upon a Time: Life — the Cell." Once Upon A Time. Video (11:41) https://youtu.be/ tjFtXXLC2bs
- Light, Douglas B. Cells, Tissues, and Skin. Human Body: How it Works Series. http:// amzn.com/1604133708

Optional Multimedia Resources

- "Plant Cells." Crash Course.
- "Tour of the Cell." Bozeman Science. Video (14.16) https://youtu.be/1Z9pqST72is
- Other books from the Human Body: How it Works Series

Before the Lesson/ Background Information

- Print out copies of Animal Cell Model worksheet http://www.cellsalive.com/worksheets/ Animal-CellModel.pdf .
- Print out any copy of an animal cell model for student reference or put one on the overhead projector.

The Lesson

Part 1: Exploring Cells (40 mins)

1. Show "Eukarypolis" and have the students go through the cell worksheets and games.
2. Pass around the animal and plant cell models for examination. Discuss the differences between animal and plant cells.
3. Watch "Once Upon a Time: Life — the Cell". Afterwards, have students identify the characters in the cartoon.
4. Watch "Plant Cells" if you have time.
5. Have cells look at a green leaf under a microscope. Can they find the cells? Do the cells look different in the leaf and the stem?
6. Have the students look for organisms in soil or other materials using the microscope (optional).
7. Next, students should investigate animal cell samples.

Part 2: Specialized Cell Research (20 mins)

1. Split the class into small research teams of about three students.
2. Each team will pick a different type of specialized animal cell (skin, red blood cell, etc.) and do independent research on that cell's structure and function.

Part 3: Building the Cell City (60 minutes)

1. Armed with their research from the previous class session, each team will work together to build a "city" that is a model of their chosen specialized cell. They should give it a fun name (like Eukaryopolis) and have fun giving it a signature look with paints, flags, etc.
2. Discuss the use of models in science. One purpose of models is to show and describe the function, appearance, and behaviors of microscopic particles.
3. Each team will write an accompanying description of their cell's function.
4. Display cell constructions with their accompanying descriptions.

Homework:

- Students will work on their reading and book report for the end of the semester.
- Assign readings from Food, Genes, and Culture.

Figure 4: Image from Tutorvista

Lesson 5: Engineered Life

Suggested Time: 60 mins

Overview

Students will start with the basics of DNA, looking at its chemical components and relating it to the big picture of how all life works and sustains itself. Then, working in groups, they will build models of the DNA Double Helix and the transcription process, and extract their own autosomal DNA just like in a laboratory.

Vocabulary

- Genes
- Deoxyribonucleic Acid (DNA)
- Nucleotide strands
- Double helix
- Bonds
- Nitrogenous Bases
- Nutrition
- Nutrigenomics
- Replication
- Transcription
- RNA
- Mitosis
- Meiosis
- Autosomal DNA
- Dominant and recessive traits
- Inheritance
- Chromosomes

Objectives

- Students will learn that DNA is the building block of life in all organisms.
- Students will consider DNA from an interdisciplinary perspective, including chemistry and nutritional science.
- Students will make a link between the sun's energy and DNA, reinforcing their grasp of food webs and the cycle of life.
- Students will understand the biology of inheritance.

Required Project Materials

- Toothpicks
- Round balls of any material (styrofoam, rubber, textile) of various colors
- Glue
- Color pens or pencils and paper
- DNA, Replications and Transcriptions Set. http://amzn.com/B000O8Z7UQ
- DNA Necklace Extraction Kit. http://www.carolina.com/dna-extraction-quantification- kits/dna-necklace-classroom-kit/211138.pr or Genes in a Bottle Kit http://www.bio- rad.com/en-us/product/genes-bottle-kit

Multimedia Resources

- "What is DNA and How Does it Work?" Stated Clearly video (5.23) https://youtu.be/ zwibgNGe4aY
- "The Science of Candy." Exploratorium. Interactive website. https:// www.exploratorium.edu/cooking/candy/sugar.htm
- "Food4Me Science." Interactive website. http://www.food4me.org/about/nutrigenomics
- Nabhan, Gary Paul. Food, Genes, and Culture: Eating Right for your Origins . http:// amzn.com/1610914929
- "List of Organisms by Chromosome Count." https://en.wikipedia.org/wiki/ List_of_organisms_by_chromosome_count
- "Mike's New Car." Monster's Inc Short Film (Disney Studios). Video (3.48) https:// youtu.be/WBkK4rg_w0U
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- "Tiki's Guide to Genetic Engineering." Interactive website. http://tiki.oneworld.net/ genetics/home.html
- "Agriculture's Sustainable Future: Breeding Better Crops." Scientific American. http:// www.scientificamerican.com/art sustainable-future/

Optional Multimedia Resources

- Punnett square: http://scienceprimer.com/punnett-square-calculator

Before the Lesson/ Background Information

- DNA is made up of molecules called **nucleotides** . Each nucleotide contains a **phosphate** group, a **sugar** group and a **nitrogen** base. The four types of **nitrogen** bases are **adenine (A)** , **thymine (T)** , **guanine (G)** and **cytosine (C)** . The order of these bases is what determines DNA's instructions, or genetic code.
- Choose lessons and activities from the DNA, Replications and Transcriptions set. Pair with readings, puzzles, and other activities from Learning About DNA .
- Choose lessons and activities from the DNA Necklace or Genes in a Bottle kit.
- Read "Tiki's Guide to GE" and "Agriculture's Sustainable Future: Breeding Better Crops."

The Lesson

Part 1: Genes and Food (20 mins)

1. Show "What is DNA and How Does it Work?" Go back over the vocabulary and concepts.
2. What does food have to do with DNA? What does the cell use as its fuel source? Does DNA dictate what kinds of food you can eat? Allow students to explore "The Science of Candy" and "Food4Me Science". Introduce the book Food, Genes, and Culture: Eating Right for Your Origins .

Part 2: DNA Laboratory (40 mins)*

1. Students will perform experiments from the DNA extraction kit or build models using the DNA Replications and Transcriptions set.

*Students may conduct activities using the DNA Laboratory kits throughout the semester, as they have time. Pepper appropriate assignments throughout the semester depending on your students' interests.

Homework:

- Students will work on their reading and book report for the end of the semester.
- Assign readings from Genetic Engineering.

Figure 5: Image from Wikipedia

Lesson 6: Genetic Engineering

Suggested Time: 60 mins

Overview

Students will become familiar with genetic engineering and the current debate over GMOs (or genetically modified organisms), then form debate teams around this topic in order to come up with compromises and beneficial solutions.

Vocabulary

- Genetic engineering
- Genetically modified organisms (GMOs)
- Cross-breeding
- Biotechnology

Objectives

- Students will apply critical thinking skills to the GMO debate.
- Students will learn about genetically modified organisms.

Required Project Materials

- Debate rubric

Multimedia Resources

- Merino, Noel. Genetic Engineering (Opposing Viewpoints). http://amzn.com/ 0737764252
- "Agriculture's Sustainable Future: Breeding Better Crops." Scientific American. http:// www.scientificamerican.com/art sustainable-future/

Optional Multimedia Resources

- "Tiki's Guide to Genetic Engineering." Interactive website. http://tiki.oneworld.net/ genetics/home.html

Before the Lesson/ Background Information

- Select major points from Genetic Engineering .
- Read "Tiki's Guide to GE" and "Agriculture's Sustainable Future: Breeding Better Crops."

The Lesson

Part 1: Genetic Engineering (20 mins)

1. As necessary, students will interact with "Tiki's Guide to Genetic Engineering." Start with "Welcome to Gene Tinkering" at http://tiki.oneworld.net/genetics/GE5.html and use the bottom right arrow to read through "So What is Genetic Engineering?", followed by "What's Wrong with Genetic Engineering?", "Why the Rush?", and "What the Companies are Making Now?", "Poisonous Plants," "Scattering Genes," and "What About the Future?"
2. Go over a few main points from Scientific American's "Agriculture's Sustainable Future: Breeding Better Crops."
3. Review readings from Genetic Engineering .

Part 2: Debate Teams (40 mins)

1. Ask the students what their opinions are on GE now that they've learned this information. If some are pro and some are against, separate them into debate teams. Structure the debate so that each side has to present their argument and then respond to the other's arguments. Neutral or deciding students can serve as the judges.
2. If everyone is neutral or sees both sides, or most people agree on one side, lead a mock debate and ask students to use the arguments each side would make.
3. To further challenge your students, have them argue the viewpoint that is opposite of what they personally believe.
4. Score the debate using a standard rubric.
5. Work with the class to come up with a safer, slower way to develop GE. What are some compromises and solutions that should be put into place?
6. Ask the students: what are the interests of each type of person involved in this debate? What if you operated a family farm? What if you were a GE scientist? What if you were a corporate executive?
7. Have the two debate teams work together to draw up a written agreement on how to move forward with GE in an ethical manner.

Homework:

- Students will work on their reading and book report for the end of the semester.
- Assign reading from Chapter 1 and 2 from Stem Cells: an Insider's Guide.

Lesson 7: Stem Cells

Suggested Time: 60 mins

Overview

Students will learn about stem cells and their many applications in medicine and science.

Vocabulary

- Multicellular organism
- Specialized cell
- Stem cell
- Adult stem cell
- Embryonic stem cell
- Somatic cell
- Bioengineering

Objectives

- Students will apply critical thinking skills to the medical use of stem cells.
- Students will learn about specialized and stem cells.

Required Project Materials

- Debate rubric (available online or develop your own)

Multimedia Resources

- Knoepfler, Paul. Stem Cells: an Insider's Guide . http://amzn.com/9814508802
- "Acid Shock Converts Adult Cells to Stem Cells." http://www.genengnews.com/gen- news-highlights/acid-shock-converts-adult-cells-to-stem-cells/81249434/ , or similar article from journal Nature or other.
- "Bioengineering" game at Centre of the Cell https://www.centreofthecell.org/learn-play/ games/bioengineering/
- Other biomedical games: https://www.centreofthecell.org/learn-play/games/

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Print out copies of sections of Chapter 3 from Stem Cells .
- Print out the cell conversion article.

The Lesson

Part 1: Stem Cells (30 mins)

1. Review material from Chapters 1 and 2 of Stem Cells .
2. Each student will take a different section from Chapter 3. For example, one student will read "Stem Cells May Greatly Reduce the Need for Animal Research Via Modeling," while someone else will read "Cell Fusion and Confusion of Cell Identity". Allow a few minutes for reading, then go around the room. Each student will share a brief summary of what they just read.
3. If you have more students than chapter sections, have the students pair up, or use sections from Chapters 4 and 5 as well.
4. Summarize "Acid Shock Converts Adult Cells to Stem Cells." What does this mean for the medical sciences? How is it related to engineering?

Part 2: Stem Cell Engineers (30 mins)

1. In pairs, students will play the "Bioengineering" game. Who can solve the problem first? Are there different ways to solve the problem? What are they?
2. Allow students to explore other games on the site, such as "Become a Medical Engineer" and "How are Drugs Developed?", "Produce a Drug Target," and "Develop a Drug."
3. Allow 10 minutes at the end of class for discussion. Ask: what are the various kinds of treatments the students explored? How does stem cell treatment compare with other kinds of treatment? Are there any ailments they treated that could also have been treated using stem cells? What are the advantages and disadvantages of stem cell treatments?

Homework:

- Students will work on their reading and book report for the end of the semester.
- Assign reading from Stem Cells: an Insider's Guide.

Lesson 8: Laboratory Field Trip

Suggested Time: 60 minutes

Overview

Students will visit a medical laboratory or medical imaging center, and learn about the various equipment, machines, and tools that are used there. Then, each student will select a machine or piece of equipment to study and report back on its history, how it's made, function in the laboratory, and other approaches to that same function.

Vocabulary (may vary)

- Microscope
- Pipettes
- Flask
- Test tubes
- Beaker
- Petri dish
- Burette
- Colorimeter
- Centrifuge
- Gel electrophoresis apparatus
- Chromatograph
- Biomedical electronics
- Clinical engineering
- Medical imaging

Objectives

- Students will learn about the importance and function of machines, programming, and technical expertise in biomedical engineering.
- Students will become familiar with laboratory and/or medical imaging equipment.

Required Project Materials

- Gloves, eyeglasses, and any other safety equipment

Multimedia Resources

- None

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Arrange for a field trip at a medical imaging center and/or a medical laboratory.

The Lesson

Part 1: Field Trip (60 - 120 mins)

1. Instruct students to come up with questions for the laboratory technician or other staff guide.
2. Provide safety lecture and equipment.
3. Each student will write a list of vocabulary and definitions.

4. Instruct each student to select a machine or piece of equipment in the laboratory. They will need to conduct their own research and write a short one-page report on the history, material, and function of that equipment during the next class session. Where possible, they should also include any alternative or new approaches to dealing with this function.

Homework:

- Report on the history, material, and function of a machine or laboratory equipment.
- Assign readings from The Future of the Mind.
- Students will work on their reading and book report for the end of the semester.

Lesson 9: Digital Hearts and Minds: 3D Printing

Suggested Time: 60 minutes

Overview

Students will learn how 3D printing works, discover its medical applications, and explore CAD software.

Vocabulary

- 3D printing
- 3D modeling
- Additive manufacturing
- Computer Aided Design (CAD)

Objectives

- Students will learn about the importance and function of machines, programming, and technical expertise in biomedical engineering.
- Students will become familiar with 3D printing and modeling.

Required Project Materials

- Sketchup 3D Modeling program: http://www.sketchup.com
- Computer lab with Sketchup installed

Multimedia Resources

- Videos, graphs, and text at "What is 3D Printing?" http://3dprinting.com/what-is-3d- printing/
- "Breakthrough in Heart Technology." http://www.childrensdmc.org/3DHeart
- "The Chemputer That Could Print Out Any Drug." The Guardian. http:// www.theguardian.com/science/2012/jul/21/ that-prints-out-drugs

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- If possible, arrange for a trip to see a 3D printer in action, or have a 3D printer technician or CAD designer assist with the lesson.
- Print articles and share "What is 3D printing" on an overhead or projector so that you can work through the article and show videos.
- Download Sketchup to class computers and make sure it works.

The Lesson

Part 1: 3D Printing (20 mins)

1. After allowing the students to turn in or share their reports from the previous class session, read through "What is 3D Printing" with the class and show the videos.
2. Separate the class into two reading groups. Distribute the "Heart Technology" and "Chemputer" articles, one article per group. After reading and discussing the articles, each group will summarize the article for the class.
3. Discuss other possible medical applications for 3D printing.

Part 2: CAD Modeling (40 mins)

1. Students will explore the CAD software, Sketchup.
2. If you have access to a 3D printer or have identified a location for a field trip, students may design a few models to be printed (depending on the parameters for using the printer, and resources available).

Homework:

- Assign readings from The Future of the Mind.
- Students will work on their reading and book report for the end of the semester.

Lesson 10-11: Prosthetics, Bionics, and Biomimicry

Suggested Time: 120-180 minutes

Overview

Students will learn about the relationship between bionics (the study of natural processes and movements for the purpose of engineering and medical applications) and the development of prosthetics for treatment of missing limbs and organs.

Vocabulary

- Bionics
- Movement research
- Prosthetics
- Biomimicry
- Neural engineering
- Neuroscience

Objectives

- Students will learn how the observation of natural traits and processes can lead to innovations in engineering.
- Students will learn how neural engineering and neuroscience links medical engineering and robotics.

Required Project Materials

- Computer lab or shared class computer and screen
- Clay and toothpicks (for building anatomical models)
- Anatomical charts of hands, feet, arms, and legs, such as those available at WebMD (http://www.webmd.com/pain-management/picture-of-the-feet)
- Remote Control Machines Kit. National Geographic Store http:// shop.nationalgeographic.com/ngs/product/kids/toys-and-games/all-toys/remote-control- machines-kit?code=SR50002
- Mindflex Game http://amzn.com/B001UEUHCG or Duel Game http://amzn.com/ B004GHNFKK and/or one of the other devices listed in the Scientific American article

Multimedia Resources

- "Sea Turtle Gets New Lease on Life with Prosthetic Flippers. BBC, various other sources available as well. http://www.bbc.com/news/world-asia-21434189
- "Prosthetic Limbs, Controlled by Thought" article and "The Bionic Man" short film. New York Times Video (8.36) http://www.nytimes.com/2015/05/21/technology/a-bionic- approach-to-prosthetics-controlled-by-thought.html?_r=0
- "Trouble Walking? Try Honda's New Exoskeleton Legs." https://youtu.be/6pWvxA4jvbc
- "Six Electronic Devices You Can Control With Your Thoughts." Scientific American. http://www.scientificamerican.com 6-electronic-devices-you-can-control- with-your-thoughts/
- Owning It: Stories About Teens With Disabilities . Donald Gallo. http://amzn.com/ 076364661X
- Kaku, Michio. The Future of the Mind. http://amzn.com/0307473341

Optional Multimedia Resources

- EPOC Emotiv with software development tools. https://emotiv.com/epoc.php

Before the Lesson/ Background Information

- Print out copies of the articles.

- Print three chapters from Owning It for group discussion, focusing on physical disabilities that can be aided with prosthetics.
- Select appropriate tasks and builds from the Remote Control Machines Kit manual.

The Lesson

Part 1: Experiencing Disability (15 mins)

1. Separate the class into three groups. Circulate the chapters from Owning It : one chapter per group. If the chapters are long, allow individuals to take different sections for more efficient reading.
2. Each group will discuss their chapter and write down a summary.
3. Each group will share their summary with the class.
4. Discuss the chapters in class. What would it be like to live with this disability? What kinds of prosthetics are available that may help a person to live differently? What are some reasons some people may not want to adjust or improve an "impairment" (e.g., feeling a sense of community or heightened abilities in other areas).
5. If appropriate, lead an activity where students explore what it's like to have a particular disability. (For example, have students put on blindfolds and attempt to walk down the hallway or to the bathroom without vision.)
6. If you have any disabled students, do NOT single them out or ask them to represent the experience to their classmates unless they feel comfortable volunteering the information. Instead, you may ask the entire class if they have any stories to share regarding disabilities — something they've experienced themselves or something involving a family member, for example.

Part 2: Prosthetic Limbs (45 mins)

1. Show the "Sea Turtle" video(s) and "The Bionic Man" short film.
2. Discuss the material that was used to make the sea turtle flipper (polyurethane). What are the properties of the material that made it an ideal choice? What did scientists have to observe in order to make an adequate prosthetic flipper? How did they test it? Allow the students to look for more information on this subject on their own, if they wish.
3. Read and discuss the New York Times article about the bionic man who controls his prosthetics with thought. There are many of these kinds of prosthetics under development. What kinds of engineering are involved in making a product like this? What other fields of study are involved? How does this connect with the field of robotics?
4. Read the "Trouble Walking?" article with the class. Note that the robotic legs are described as an exoskeleton. What is an exoskeleton? How did scientists find out about exoskeletons? Here, make a connection with observations of physical structures in nature, as well as their traits, functions, and even aesthetics.
5. Brainstorm with the class about different animals they know. What physical traits and behaviors would be useful in application to engineering and medicine?
6. Separate the students into two teams: hands and feet. If you have a large class, try four teams and add elbows/arms and knees/legs. Using clay, each team will build an anatomical model of their body part. They will research current prosthetics available for that part. At the end of class, have each team spend about two minutes showing what they learned and discussing how prosthetics attempt to replicate the function of the particular part.

Part 3: Robot Builds (60-120 mins)

1. Allow a few minutes for discussion of devices that can be mind-controlled. How is this accomplished? Relate to neural engineering and neuroscience.
2. Allow students to play the mind-controlled devices. If you have students interested in or advanced in software development and programming, consider purchasing EPOC Emotiv or similar.
3. Using the National Geographic kit, students will build remote-control machines.

4. Relate this activity to the mind-controlled machines and relationship between neuroscience and prosthetics.

Homework:

- Assign readings from The Future of the Mind.
- Students will work on their reading and book report for the end of the semester.

Lesson 12: Final Book Reports

Suggested Time: 60 minutes

Overview

Students will share their final presentations on the books they read throughout the semester. Presentation and book report should include a summary of the text, and a critique.

Objectives

- Students will gain speaking and presentation skills.

Multimedia Resources

- None

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- None

The Lesson

Part 1: Presentations (60 mins)

1. Each student will present their final book report. Assign time allotments based on the number of students.
2. Encourage the use of visuals and supplementary materials.

Optional Lesson. Software Programming Laboratory

Suggested Time: 60 mins

Overview

Students will use various programs to practice coding, working at different levels depending on the individual.

Vocabulary

- Computer
- Data/information
- Input
- Output
- Programming language
- Code
- Loops
- Conditionals
- Branching
- Iterative repetition

Objectives

- Students will learn basic programming concepts and advance to intermediate level.
- Students will begin to code real programs.

Required Project Materials

- Apple devices that can use apps (iPad, iPod Touch)
- Bee Bot app, available on iTunes: https://itunes.apple.com/us/app/bee-bot/id500131639? mt=8
- Daisy the Dinosaur: https://itunes.apple.com/us/app/daisy-the-dinosaur/id490514278? mt=8
- Scratch (free): https://scratch.mit.edu
- Hopscotch: https://www.gethopscotch.com and Tynker: https://www.tynker.com
- Sidewalk chalk
- Codea: http://twolivesleft.com/Codea/

Multimedia Resources

- "How to Play Hopscotch." http://www.wikihow.com/Play-Hopscotch

Optional Multimedia Resources

- Kodable School (as supplement): https://www.kodable.com
- For more inspiration and resources: http://code.org

Before the Lesson/ Background Information

- Download Bee Bot and Daisy the Dinosaur, and enroll the class in Scratch, which is free.
- Explore the Scratch website for inspiration and to get familiar with the tools.
- Download and explore Hopskotch, Tynker (only available to schools), and Codea.
- Prior to Weeks 8 and 9, develop a feedback questionnaire to encourage revision and further creative development.

The Lesson

Part 1: Beginners: Bee and Daisy (Time varies)

1. After Bee Bot, move on to Daisy the Dinosaur in Challenge Mode, which will take them through a series of educational steps. Then move on to Free Play after that.

2. If any students are already past this level, allow them to begin at intermediate.

Part 2: Intermediate: Programming With Scratch (Time varies)

1. Scratch will teach the students terminology and concepts that will provide the foundation for advanced programming. Allow them to experiment and create at their own pace.

Part 3: Intermediate Plus: Programming With Hopscotch/ Tynker (Time varies)

1. Students will move on from Scratch to Hopscotch/ Tynker. Each student will program a game!
2. Take the students outside for an old-school game of Hopscotch. Show the Hopscotch video and historical information, if necessary. Show them how to draw the lines with chalk. After playing the game, can they determine why the program is called that? What are the similarities between Hopscotch, the physical game, and the coding program? What makes the game fun?
3. Students will exhibit their games at the end of each week. Have a peer review process in place so that each creator will obtain feedback from peers.
4. Expose students to Codea. Instead of using blocks, students work with the actual source code in this program. **More advanced students can start on Codea as soon as they are ready.**

Vocabulary Definitions

Lesson 1: Biomedical Engineering: Introduction Vocabulary

- Biomedical engineering - (BME) is the application of **engineering** principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). -
- Biomechanics - **Biomechanics** is the study of the structure and function of biological systems by means of the methods of "mechanics" (the branch of physics involving analysis of the actions of forces).
- Tissue engineering - **Tissue engineering** evolved from the field of biomaterials development and refers to the practice of combining scaffolds, cells, and biologically active molecules into functional **tissues** .
- Genetic engineering - the group of applied techniques of genetics and biotechnology used to cut up and join together genetic material and especially DNA from one or more species of organism and to introduce the result into an organism in order to change one or more of its characteristics.
- Neural engineering - **Neural engineering** (also known as neuroengineering) is a discipline within biomedical **engineering** that uses **engineering** techniques to understand, repair, replace, enhance, or otherwise exploit the properties of **neural** systems.
- Pharmaceutical engineering - **Pharmaceutical engineering** is a branch of **pharmaceutical** science and technology that involves development and manufacturing of products, processes, and components in the **pharmaceuticals** industry (i.e. drugs & biologics).
- Medical device - A **medical device** is an instrument, apparatus, implant, in vitro reagent, or similar or related article that is used to diagnose, prevent, or treat disease or other conditions, and does not achieve its purposes through chemical action within or on the body (which would make it a drug).
- Medical imaging - **Medical imaging** is the technique and process of creating visual representations of the interior of a body for clinical analysis and **medical** intervention. **Medical imaging** seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease.
- Clinical engineering - **Clinical engineering** is a speciality within biomedical **engineering** responsible primarily for applying and implementing medical technology to optimize healthcare delivery.

Lesson 2: Anatomy and Osteology Vocabulary

- Anatomy - a branch of morphology that deals with the structure of organisms .
- Osteology - a branch of anatomy dealing with the bones.
- Skeletal system - includes all of the bones and joints in the body.
- Endocrine system - The **endocrine system** is the collection of glands that produce hormones that regulate metabolism, growth and development, tissue function, sexual function, reproduction, sleep, and mood, among other things.
- Muscular system - The **muscular system** is an organ **system** consisting of skeletal, smooth and cardiac **muscles** . It permits movement of the body, maintains posture, and circulates blood throughout the body.
- Cardiovascular system - The **circulatory system** , also called the **cardiovascular system** , is an organ **system** that permits blood to circulate and transport nutrients (such as amino acids and electrolytes), oxygen, carbon dioxide, hormones, and blood cells to and from cells in the body.
- Integumentary system - The **integumentary system** is the organ **system** that protects the body from various kinds of damage, such as loss of water or abrasion from outside. The **system** comprises the skin and its appendages (including hair, scales, feathers, hooves, and nails).
- Nervous system - the network of nerve cells and fibers that transmits nerve impulses between parts of the body.

Lesson 3-4: Eukaryopolis Vocabulary

- Organism - an individual living thing

- Single-celled organism - an organism consisting of one cell.
- Multicellular organism - an organism consisting of multiple cells.
- Cell - a small usually microscopic mass of protoplasm bounded externally by a semipermeable membrane, usually including one or more nuclei and various other organelles with their products, capable alone or interacting with other cells of performing all the fundamental functions of life, and forming the smallest structural unit of living matter capable of functioning independently.
- Eukaryotic (animal cell) - A eukaryote is any organism whose cells contain a nucleus and other organelles enclosed within membranes.
- Organelle - a specialized cellular part (as a mitochondrion, lysosome, or ribosome) that is analogous to an organ
- Mitochondria - any of various round or long cellular organelles of most eukaryotes that are found outside the nucleus, produce energy for the cell through cellular respiration, and are rich in fats, proteins, and enzymes.
- Ribosomes - any of the RNA-rich cytoplasmic granules that are sites of protein synthesis.
- Cytoplasm - the organized complex of inorganic and organic substances external to the nuclear membrane of a cell and including the cytosol and membrane-bound organelles (as mitochondria or chloroplasts).
- Endoplasmic Reticulum - a system of interconnected vesicular and lamellar cytoplasmic membranes that functions especially in the transport of materials within the cell and that is studded with ribosomes in some places.
- Golgi Apparatus - a cytoplasmic organelle that consists of a stack of smooth membranous saccules and associated vesicles and that is active in the modification and transport of proteins
- Lysosome - a saclike cellular organelle that contains various hydrolytic enzymes
- DNA (deoxyribonucleic acid) - a substance that carries genetic information in the cells of plants and animals
- RNA - Ribonucleic acid (**RNA**) is a polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes. **RNA** and DNA are nucleic acids, and, along with proteins and carbohydrates, constitute the three major macromolecules essential for all known forms of life.
- RNA transcription - **Transcription** is the first step of gene expression, in which a particular segment of DNA is copied into **RNA** (mRNA) by the enzyme **RNA** polymerase.
- Centrosomes - an organelle that is the main place where cell microtubules get organized. They occur only in animal cells. Also, it regulates the cell division cycle, the stages which lead up to cell division.
- Nucleus - the central and most important part of an object, movement, or group, forming the basis for its activity and growth.

Lesson 5: Engineered Life Vocabulary

- Gene - A **gene, made up of DNA,** is the basic physical and functional unit of heredity.
- Deoxyribonucleic Acid (DNA) - a molecule that carries most of the genetic instructions used in the development, functioning and reproduction of all known living organisms and many viruses
- Nucleotides - organic molecules that serve as the monomers, or subunits, of nucleic acids like DNA and RNA. The building blocks of nucleic acids, **nucleotides** are composed of a nitrogenous base, a five-carbon sugar (ribose or deoxyribose), and at least one phosphate group.
- Double helix - the shape of a DNA strand.
- Bonds - the bridges of the helix, made up of sugar and phosphate molecules.
- Nitrogenous Bases - nitrogen-containing molecules that form the building blocks of DNA and RNA: adenine, guanine, cytosine, thymine and uracil
- Nutrition - the science that interprets the interaction of nutrients and other substances in food.
- Nutrigenomics - a branch of nutritional genomics and is the study of the effects of foods and food constituents on gene expression.
- Replication - **DNA replication** is the process of producing two identical replicas from one original

DNA molecule.

- Transcription - a particular segment of **DNA** is copied into RNA (mRNA) by the enzyme RNA polymerase
- RNA - Ribonucleic acid (**RNA**) is a polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes. **RNA** and DNA are nucleic acids, and, along with proteins and carbohydrates, constitute the three major macromolecules essential for all known forms of life.
- Mitosis - a part of the cell cycle in which chromosomes in a cell nucleus are separated into two identical sets of chromosomes, and each set ends up in its own nucleus.
- Meiosis - a type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell, as in the production of gametes and plant spores.
- Autosomal DNA - Describes the chromosomes that are not allosomes, or sex chromosomes. Humans have 22 pairs of autosomes and one pair of allosomes (the X chromosome and the Y chromosome).
- Dominant and recessive traits - A dominant trait is one that will appear in the offspring if one of the parents contributes it. Recessive traits require two copies to appear.
- Inheritance/heredity - Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.
- Chromosomes - thread-like structures located inside the nucleus of animal and plant cells. Each **chromosome** is made of protein and a single molecule of deoxyribonucleic acid (DNA) and is passed from parents to offspring.

Lesson 6: Genetic Engineering Vocabulary

- Genetic engineering - the **modification** of an organism's **genetic** composition by artificial means, often involving the transfer of specific traits, or **genes** , from one organism into a plant or animal of an entirely different species
- Genetically modified organisms (GMOs) - living organisms whose genetic material has been artificially manipulated in a laboratory through genetic engineering, or GE
- Cross-breeding - hybridization of one organism (a breed, species, or variety) with another through breeding.
- Biotechnology - the use of living systems and organisms to develop or make products.

Lesson 7: Stem Cells Vocabulary

- Multicellular organism - is composed of many **specialized cells.**
- Specialized cell - **Specialized cells** differ in structure (size, shape. . .) and function (the role they perform in the organism). The structural modifications that occur in a **specialized cell** equip it to do its job in the organism.
- Stem cell - an undifferentiated cell of a multicellular organism that is capable of giving rise to indefinitely more cells of the same type, and from which certain other kinds of cell arise by differentiation.
- Adult stem cell - can only become certain kinds of specialized cells unless specially treated
- Embryonic stem cell - can become any kind of specialized cell
- Somatic cell - any **cell** of the body except sperm and egg **cells**
- Bioengineering - another term for biomedical engineering

Lesson 8: Laboratory Field Trip Vocabulary (for example)

- Microscope
- Pipettes
- Flask
- Test tubes

- Beaker
- Petri dish
- Burette
- Colorimeter
- Centrifuge
- Gel electrophoresis apparatus
- Chromatograph
- Biomedical electronics
- Clinical engineering
- Medical imaging

Lesson 9: Digital Hearts and Minds: 3D Printing Vocabulary

- 3D printing - a process of making three dimensional solid objects from a digital file.
- 3D modeling - the process of developing a mathematical representation of any three- dimensional **surface** of an object (either inanimate or living) via specialized software.
- Additive manufacturing - the formal term for 3D printing.
- Computer Aided Design (CAD) - the use of computer programs to create two- or three- dimensional (2D or 3D) graphical representations of physical objects.

Lesson 10-11: Prosthetics, Bionics, and Biomimicry Vocabulary

- Bionics - the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology.
- Movement research - the study, analysis, and animation of all forms of **movement.**
- Prosthetics - an artificial body part; a prosthesis.
- Biomimicry - the design and production of materials, structures, and systems that are modeled on biological entities and processes.
- Neural engineering - a discipline within biomedical **engineering** that uses **engineering** techniques to understand, repair, replace, enhance, or otherwise exploit the properties of **neural** systems.
- Neuroscience - any or all of the sciences, such as neurochemistry and experimental psychology, which deal with the structure or function of the nervous system and brain.

Optional Lesson. Software Programming Laboratory Vocabulary

- Computer
- Data/information
- Input
- Output
- Programming language
- Code
- Loops
- Conditionals
- Branching
- Iterative repetition

Weekly Quizzes

Lesson 1: Biomedical Engineering: Introduction Quiz

Match the vocabulary terms with their definitions: (4 points)

Medical imaging	the group of applied techniques of genetics and biotechnology used to cut up and join together genetic material in order to change one or more of an organism's characteristics
Medical devices	the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention
Biomechanics	the study of the structure and function of biological systems by means of the methods of "mechanics"
Genetic engineering	an instrument, apparatus, implant, in vitro reagent, or similar or related article that is used to diagnose, prevent, or treat disease or other conditions

1. In your own words, describe biomedical engineering. Name and define at least three subfields. (4 points)
2. Describe something you found interesting about the field of biomedical engineering. Go into as much detail as possible. (2 points)

Lesson 2: Anatomy and Osteology Quiz

Match the vocabulary terms with their definitions: (4 points)

Muscular system	includes all of the bones and joints in the body
Integumentary system	a branch of anatomy dealing with the bones
Skeletal system	an organ **system** consisting of skeletal, smooth and cardiac **muscles**. It permits movement of the

Osteology the organ system that protects the body from various kinds of damage, such as loss of water or abrasion from outside. The system comprises the skin and its appendages (including hair, scales, feathers, hooves, and nails).

1. Describe in your own words the following systems: the endocrine system, the cardiovascular system, and the nervous system. (3 points)
2. What is the difference between anatomy and osteology? (2 points)
3. Name one organ in the cardiovascular system. (1 point)

Lesson 3-4: Eukaryopolis Quiz

Match the vocabulary terms with their definitions: (4 points)

DNA (deoxyribonucl eic acid)	Transcription is the first step of gene expression, in which a particular segment of DNA is copied into RNA (mRNA) by the enzyme RNA polymerase
RNA	a substance that carries genetic information in the cells of plants and animals
transcription	
Ribosomes	any of various round or long cellular organelles of most eukaryotes that are found outside the nucleus, produce energy for the cell through cellular respiration, and are rich in fats, proteins, and enzymes
Mitochondria	any of the RNA-rich cytoplasmic granules that are sites of protein synthesis

1. What is a eukaryote (or eukaryotic cell)? (1 point)

2. Draw a diagram of a cell, naming its parts and using as much detail as possible. (5 points)

Lesson 5: Engineering Life Quiz:

Match the vocabulary terms with their definitions: (4 points)

Gene	Describes the chromosomes that are not allosomes, or sex chromosomes
Autosomal DNA	a molecule that carries most of the genetic instructions used in the development, functioni
Deoxyribonucl eic Acid (DNA)	made of DNA, the basic physical and functional unit of heredity
Chromosomes	Thread-like structures located inside the nucleus of animal and plant cells. Each **chromos**

1. Explain what food has to do with DNA. Include the term nutrigenomics in your answer. (2 points)
2. Draw a diagram of a DNA strand, naming its parts and using as much detail as possible. (2 points)
3. What is the difference between DNA and RNA? (1 point)
4. Describe an experiment you conducted in class, or a model you built, and what you learned from it. (1 point)

*Adjust questions depending on the focus of the lesson. For example, you may want to substitute questions about RNA replication and transcription if the students performed more experiments in this area.

Lesson 6: Genetic Engineering Quiz

Match the vocabulary terms with their definitions: (4 points)

Biotechnology	the **modification** of an organism's **genetic** composition by artificial means, ofte
Cross-breeding	living organisms whose genetic material has been artificially manipulated in a lab
Genetic engineering	hybridization of one organism (a breed, species, or variety) with another through
Genetically modified organisms (GMOs)	the use of living systems and organisms to develop or make products

1. Describe the pros and cons of genetic engineering. (4 points)
2. What are some non-GE ways to improve crops and practice sustainable agriculture? (2 points)

Lesson 7: Stem Cell Quiz

Match the vocabulary terms with their definitions: (4 points)

Specialized cell	differs in structure (size, shape. . .) and function (the role they perform in the organism)
Embryonic stem cell	can only become certain kinds of specialized cells unless specially treated
Genetic engineering	any **cell** of the body except sperm and egg **cells**
Adult stem cell	can become any kind of specialized cell

1. Describe some potential medical applications of stem cell research. (4 points)
2. How does stem cell treatment compare with other kinds of treatment? (2 points)

Lesson 8: Laboratory Field Trip Vocabulary Quiz:

1. List five items you found in the laboratory and their definitions/functions. (5 points)
2. Describe the safety equipment and procedures used in the laboratory. (3 points)
3. How are laboratories important to biomedical engineering? (2 points)

Lesson 9: Digital Hearts and Minds: 3D Printing Quiz

Match the vocabulary terms with their definitions: (4 points)

Additive manufacturing	the use of computer programs to create two- or three-dimensional (2D or 3D) graphical r
3D printing	the process of developing a mathematical representation of any three- dimensional **surfac**
3D modeling	a process of making three dimensional solid objects from a digital file
Computer Aided Design (CAD)	the formal term for 3D printing

1. Describe two medical uses for 3D printing. (2 points)
2. Describe what you learned from the CAD programming exercise. How is CAD used to produce 3D models? (4 points)

Lesson 10-11: Prosthetics, Bionics, and Biomimicry Quiz

Match the vocabulary terms with their definitions: (4 points)

Bionics	the design and production of materials, structures, and systems that are modeled on biological entities
Neural engineering	the application of biological methods and systems found in nature to the study and design of engineeri
Neuroscience	a discipline within biomedical **engineering** that uses **engineering** techniques to understand, repair, r
Biomimicry	any or all of the sciences, such as neurochemistry and experimental psychology, which deal with the st

1. Describe how bionics and biomimicry are important fields of study for developing more effective prosthetics. (3 points)
2. Describe the relationship between neuroscience and biomedical engineering. (3 points)

Optional Lesson. Software Programming Laboratory Vocabulary (have students define)

- Computer
- Data/information
- Input
- Output
- Programming language
- Code
- Loops
- Conditionals
- Branching
- Iterative repetition