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|  **Lesson Title**   |   ***Models and Simulations in Biomedical Engineering*** |
| **Grade Level:** 6th to 12th  | **Time required:** 90 minutes   | **Lesson Dependency:** None  | **Subject Areas:** Biology, Engineering, Language Art, Visual Arts.  |  |
| **Summary**   |  In this lesson students will learn about the importance of using physical and computational models and simulations in engineering. After reading about the significance of models and simulations in different areas, students will analyze the advantages of using them in the biomedical field. Guided by the instructor, students will learn how to break down a body system into its components in order to recreate a physical model to better understand how it works. Then, students will build a physical model of the urinary system that later will be used to conduct an experiment.  |
| **Engineering Connection**   |  Engineers not only design solutions, but also generate knowledge about different topics that need to be addressed. Testing and experimenting with real systems sometimes is difficult or impossible depending on the nature of the problem. Physical and computational models and simulations play an essential role in engineering. They are tools used to better understand systems and systems interactions in order to assist with the decision making process. The goal of this lesson is to introduce students to the importance of creating and building accurate models and simulations in order to learn, test, train, and make decisions based on reliable data.  |
| **Learning Objectives**   |  Students should be able to:1. Compare and contrast models and simulations
2. Describe how models and simulations are used in Biomedical Engineering
3. Create a model of a human body system
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| **Educational Standards**  | **Science and Math**    | **Engineering and Technology**     | **Art**   | **Language Arts.**   |
|  | **SC.6.L.14.5**. Identify and investigate the general functions of the major systems of the human body (digestive, respiratory, circulatory, reproductive, excretory, immune, nervous, and musculoskeletal) and describe ways these systems interact with each other to maintain homeostasis.**SC.912.L.14.48.** Describe the anatomy, histology, and physiology of the ureters, the urinary bladder and the urethra.**SC.912.CS-CS.1.5** Represent and understand natural phenomena using modeling and simulation.**MA.K12.MTR.2.1** Demonstrate understanding by representing problems in multiple ways. Mathematicians who demonstrate understanding by representing problems in multiple ways: Build understanding through modeling and using manipulatives.Represent solutions to problems in multiple ways using objects, drawings, tables, graphs and equations.Progress from modeling problems with objects and drawings to using algorithms and equations.Express connections between concepts and representations.Choose a representation based on the given context or purpose. | **CTE-HLTH.68.BIOTEC.01.06** Describe technologies associated in careers within the biotechnology research and development career pathway. | **VA.68.C.1.2** Use visual evidence and prior knowledge to reflect on multiple interpretations of works of art.**VA.912.C.1.7** Analyze challenges and identify solutions for three-dimensional structural problems. |  **ELA.6.R.2.2** Analyze the central idea(s), implied or explicit, and its development throughout a text.**ELA.7.R.2.**1Explain how individual text sections and/or features convey a purpose in texts.**ELA.8.R.2.1**Analyze how individual text sections and/or features convey a purpose and/or meaning in texts.**LAFS.68.RST.1.2** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **LAFS.910.RST.4.10** By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.**LAFS.1112.RST.1.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. |

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|  **Worksheet and attachments**  | 1. [Models and Simulations in Biomedical Engineering Visual Presentation](https://docs.google.com/presentation/d/1zOPK8OEqjqH2tD518f3D6k7h47lwSfLgehoSkby96F0/edit#slide=id.p)
2. [Worksheet 1. Instruction and Urinary System Model](https://docs.google.com/document/d/1F7Ohrr81zqezCA4VPD3tXjSbuK10PjnE/edit)
3. [DIY. Project](https://docs.google.com/document/d/1QBmU-6BDqAYIGpi1pOjizGIaOZ-r-oKxL6d0CV82AuI/edit)
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| **Material List**   | 1. A package of filter paper
2. Two plastic funnels per group
3. 2 rolls of tape
4. 1 poster board per group
5. Gun sticks and a glue gun per group
6. A small balloon per group (bladder)
7. Color pencils and markers (to label your model)
 | 1. A rubber band per group (to close the balloon)
2. A plastic container per group
3. Enough water/coffee mixture to test your model
4. Plastic and flexible tubing (enough for all groups) **\*look for tubing that can be connected to the funnels to avoid leaking**
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| **Prerequisite Knowledge**   |   |
| **Lesson background and concepts for teachers**   |  |
| **Associated Activities**   | 1. [Worksheet 1. Instruction and Urinary System Model](https://docs.google.com/document/d/1F7Ohrr81zqezCA4VPD3tXjSbuK10PjnE/edit)
2. The completion of the physical model (after instruction is delivered, students will build the urinary system model following the example from the EXPO video or their own design)
3. [DIY. Project](https://docs.google.com/document/d/1QBmU-6BDqAYIGpi1pOjizGIaOZ-r-oKxL6d0CV82AuI/edit)
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| **Lesson Closure**   |  |
| **Vocabulary/Definitions**   | 1. **Abstraction.** A strategy for simplifying a problem by identifying the essential features of a real system and representing them in a different form.
2. **decision making.** A mental or cognitive process resulting in the selection of a course of action among several alternative scenarios.
3. **Experimentation.** A methodical, trial-and-error procedure used to understand how changes in the input or operating environment affect a result.
4. **Model.** A physical, mathematical, or logical representation of something that exists in the real world.
5. **Simplification.** A technique in which unimportant details are removed in an effort to define simpler relationships.
6. **Simulation.** An approach for solving real-world problems that usually involves mathematical equations and a computer-generated solution.
7. **System.** A set of interacting pieces that respond to inputs according to a set of rules that govern the resulting behavior.
8. **systems engineering.** An engineering discipline that focuses on the way different parts of a system should coordinate and interact to achieve a desired goal.
9. **Testing.** A methodical procedure used to understand the differences between a simulation and the real world.
10. **Training.** Teaching and learning with the goal of improving real-world performance under both normal and extreme conditions.
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| **Assessments**   | **Pre-lesson assessment**   | **During the lesson assessment**   | **Post lesson assessment**   |   |
|  The instructor can informally assess students’ knowledge about the topic by conducting a Socrative seminar after watching the introductory video. Even though only two questions are displayed on the visual presentation, the instructor can add more questions to the activity.  |   |  The post lesson assessment will consist of a project that students will complete using the materials they can find at home and an oral presentation explaining the processes followed to design the model. The project can be completed individually or in groups [DIY Project.](https://docs.google.com/document/d/1QBmU-6BDqAYIGpi1pOjizGIaOZ-r-oKxL6d0CV82AuI/edit) [Rubric. DIY Project.](https://docs.google.com/document/d/14bBbIMvid3AI5dQ3qu55lujRdYfAgrD9cDQIbPAFopM/edit)  |   |

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| **Lesson Extension**  |  After building the physical model students can test how different mixtures are filtered by the kidneys. A mixture of coffee ground and water can be used as well as water and sand, and a mixture made of water and oil, too. Observations will be recorded and analyzed by students to test the efficiency of the filter paper that in that case, will represent the nephrons.  |