Name ____

Directions: As you listen to the presentation, take notes and answer the following questions.

1. Describe three ways that the body resembles a machine. What are some of its limitations?

   Possible answers:
   - Powered by a pump: heart circulates fluids via heartbeat, heart rate can speed up/slow down as needed
   - Powered by food: food that we eat is digested, broken down into carbohydrates, fats, and proteins that our body uses for energy production
   - Uses electricity to communicate: neurons send pulses of electricity to other neurons to produce brain activity
   - Senses its environment: eyes, nose, ears, fingers/skin; help detect heat, pressure, vibration, texture, vibrations in air, light intensity, odors, etc.

   Limitations:

   Possible answers:
   - Susceptible to diseases caused by viruses and bacteria
   - Can be injured (temporary or permanent)
   - Genetic mutations that lead to abnormal development or protein dysregulation
   - Body stops working as expected/organ functions begin to break down with age → body stops repairing itself

2. What is biomedical engineering? How does it address the body as a machine?

   - Application of engineering principles to medicine and biology in order to further someone's health
   - Study of biological systems → improves or recreates them to keep people healthier for longer
   - Also known as bioengineering: applying biology to medicine from engineering perspective
   - Addresses body as machine by helping "repair" the body:
     - Keeps the body running for longer by fixing broken parts
     - Slows the degradation or breakdown of body parts
     - Provides body with new sources of energy
     - Edits out defects (or prevent defects from occurring in the first place)

3. List the general steps of the BME Design Process. For each step, compare how the engineering and medical fields approach each step.

    1. Identify the problem
        - Engineering identifies the needs; medicine identifies the symptoms
        - Engineering creates a problem statement: what is the problem? Who has the problem? Why is it important?
        - Medicine uses diagnostic tests and assessments to define the problem: imaging tests, physical exams, patient histories
    2. Define the constraints
        - Engineering describes conditions that need to be met by the design solution; also limits design possibilities by excluding/requiring specifications (cost, size, weight, material, etc.)
        - Medicine describes conditions that must be met with treatment method; limits treatment options on various physiological and healthcare factors (cost, time, patient values, medical expertise, etc.)
    3. Generate ideas
        - Engineering performs research, studies existing solutions (for improvements and to find aspects that may apply in a new context), and brainstorms new solutions
        - Medicine performs research, considers alternative treatment methods (both surgical and medication), and examines existing treatment options (weighing the benefits and drawbacks of each option)
    4. Select approach
        - Engineering describes the advantages and disadvantages of each solution, weighs each solution against the design criteria and constraints to ensure that they're satisfied, then identifies the best approach
        - Medicine describes the risks and benefits of each treatment option, ensures that the treatment plan is appropriate for the specific patient's diagnosis/prognosis, then identifies the best treatment plan
    5. Develop design
        - Engineering refines the approach by revisiting the specifics of the problem; once approach is locked in, engineers establish the design structure and function → may build physical prototypes or create and run simulations (depending on approach)
        - Medicine refines the approach based on patient specifics (medical history, current symptoms, etc.); once approach is locked in, medical professionals

establish the treatment component → may design a device or develop a pharmaceutical (depending on approach)

6. Test solution
    - Engineering iterates the design process to improve their current work and identify any remaining flaws in the design; they evaluate feedback throughout the process and consider any possible improvements or upgrades to the design
    - Medicine performs clinical trials to identify any common flaws or dangers associated with the treatment; they also follow up with patients post-treatment to ensure that the treatment option was successful and that the individual outcomes were satisfactory and expected

4. What do you think is the most important ethical obligation that a biomedical engineer has? Why? Name 2-3 situations where this obligation would be relevant. *There is no single correct answer—just provide reasoning to back up your answer.*

As noted in the question, answers will vary depending on what the student holds as most important. The goal of this question is to get students thinking about and contextualizing ethical obligations in their own lives.

Possible situations:

- Use scientific knowledge for "public good"; prioritize safety, health, and public welfare when researching or providing a briefing to a group of people (for example, press briefing on public health concerns)
- Uphold prestige of the BME profession by working truthfully and competently when researching, teaching, presenting, etc.
- Keep patient information private and confidential in the office, clinic, hospital, etc.
- Consider consequences of price, availability, and delivery of healthcare when marketing new product to the medical industry
- Ensure that all guidelines and laws are followed when running animal studies or clinical models
- Appropriately cite and represent other researchers' work when including it in publications
- Present your research accurately, honestly, and clearly so that people will not be misled
- Train new undergraduates in the lab appropriately; model to new students how to publish papers and results honestly
- Avoid influence from special interests when training or producing content; keep science separate from politics, religion, etc.

Brainstorm Applications

Directions: Name a specific problem or application related to biomedical engineering (for example, a disease, treatment, medicine, device, surgery, organ, tissue type, complication, lab technique, medical instrument, etc.) that can be addressed or enhanced by BME.

1. What is the problem or application that can be solved or improved?
   Answers will vary, but complete answers will identify who has the problem/need (patient population), what the problem/need is (problem statement), and why it's important to pursue (motivation). Answers will provide appropriate context and background information and will justify why the problem must be solved or what aspect of a current solution could be improved.

2. How would information from this presentation help solve or support your problem or application? What did you hear that is most relevant?
   Answers will vary, but complete answers will reference specific slide content. Students may identify the focus area that is most relevant to their problem/need. They may also describe their problem/need in terms of a "machine" and illustrate how biomedical engineering addresses these issues (for example, by "repairing" broken parts). If relevant, students may reference historical information about the application they hope to improve (or may use the historical information as an example of an existing solution).

3. After reviewing the presentation, what questions do you still have?

   Answers will vary. Questions may ask for teachers to elaborate on the content presented, or they may point out aspects of biomedical engineering that students are interested in but that were not addressed in the presentation. This question may be useful in gauging interest and determining other lesson plans or modules to include to retain engagement.

4. How would the BME Design Process help you find a solution or improvement to the problem presented above?

   a. **Identify the problem**: What is the problem/need? Who does it impact? Why is it important?

      Answers will vary depending on the problem chosen. Ensure that students are following the general BME Design Process presented. The goal of the question is to get students working through the general thought process, and the question is meant to reveal how many aspects must be considered and addressed in an appropriate design. The grading focus should be on whether students are engaging with the general process and justifying their answers, rather than worrying about scientific accuracy. Complete answers will demonstrate critical thinking and will show that students are incorporating the lesson into their personal interests.

b. **Define the constraints**: What conditions must be met by your solution in order for it to be successful? What other specifications (cost, size, weight, material, implementation time, medical expertise, etc.) should be considered for your solution?

Answers will vary.

c. **Generate ideas**: What solutions already exist, and what aspects of these solutions can be improved upon? If no solutions exist, why haven't they been proposed yet?

Answers will vary.

d. **Select approach**: Why is your solution advantageous? How does it meet the conditions and specifications stated in part (a)? What risks and benefits does it offer? Why is it appropriate for the patient population you have in mind? Is it feasible?

Answers will vary.

e. **Develop design**: How would the solution function? What would the structure be like? *The structure does not need to be complete—just demonstrate that you've thought of how this might be executed or implemented. It may be useful to sketch out the design.*

Answers will vary.

f. **Test solution**: How might you test your solution/improvement? List 2-3 potential options. How will you know that your product is meeting the specifications? What feedback or data would you collect? What ethical considerations might you need to have when testing? *Examples such as animal testing, clinical trials, lab experiments, surveys (either before or after treatment), observations, interviews, user testing*

Answers will vary.