Biomedical Engineering Focus Areas: Application

Name: _____   **Date:** _____

Directions: For each scenario, choose two Biomedical Engineering focus areas introduced during the presentation. First, briefly describe them. Then describe how the work of researchers in each of the selected focus areas might be applied to the scenario. You can either brainstorm a new solution or research an existing solution. Be sure to include information on:

1) What the problem is,
2) How the focus areas are related to the problem,
3) The strategy an engineer in either focus area would take to solve the problem.

Scenario 1: Anthony has a motor disorder that affects his hands, limbs, torso, and speech muscles. As a result, he struggles with balancing, walking, being understood when speaking to new people, and performing fine hand movements. He hopes to gain independence in accomplishing some Activities of Daily Living (ADLs) such as personal hygiene, dressing, moving around, communicating, and eating.

Answers will vary depending on the focus areas chosen.

- Potential problems to be solved:
    - Trouble with fine hand movements
    - Issues with balance
    - Difficulties walking
    - Difficulties with speech being recognized and understood by those unfamiliar with it
    - More specific problems centered around ADLs: showering, getting dressed, moving into/out of bed or chair, communicating with others, eating or preparing food, etc.
- Possible focus areas and solutions:
    - Biomedical devices: assistive technologies that support ADLs (mobility aids, adaptive switches/utensils, specialized tools for eating/gripping/getting dressed, speech-generating devices, etc.)
    - Cellular and Molecular Biotechnology: genetic engineering/CRISPR to modify genes, eliminate the disorder to cure the disease prior to birth
    - Bioimaging and Signal Processing: brain control interface that depends on interpretation of EEG signals, which may represent different actions for assistive technology inputs; EEG signals converted to control signals for either augmentative communication device or mobility aid
    - Neuroengineering: mind control of robotic limbs to perform ADLs

Scenario 2: During rugby practice, Ramona collapses after colliding with another player. They have scrapes and bruises on their arms, and the coach thinks that the athlete may have hit their head or even broken a bone. Dr. Cacéres wants to determine where they're injured and how severe the injuries are, and also wants to heal any injuries quickly so that Ramona can get back to playing.

Answers will vary depending on the focus areas chosen.

- Potential problems to be solved:
  - Determine where they're injured (head, body, if a bone is broken, etc.)
  - Heal injuries quickly
  - Prevent future injuries with preventative equipment
- Possible focus areas and solutions:
  - Biomedical devices: band-aids, cast saw, exam light or table, IV pole, lab equipment (for analyzing tests), imaging equipment, etc.
  - Biomaterials and Tissue Engineering: wound healing biomaterials (skin substitutes), collagen biomaterials, hydrogels with embedded medicine to speed up healing
  - Cellular and Molecular Biotechnology: localized drug delivery (drug that speeds up healing process)
  - Bioimaging and Signal Processing: medical imaging (fMRI, CT, PET, EEG, fNIRS for head scan, X-ray for broken bones)

Scenario 3: Kira notices a lump in one of her breasts. Her primary care physician wants to determine the lump's location and whether it's cancerous. If the lump is malignant, the physician also wants to recommend potential treatment options to Kira.

Answers will vary depending on the focus areas chosen.

- Potential problems to be solved:
    - Identifying location of lump
    - Determining whether lump is malignant or benign
    - Ways to treat/cure cancer
- Possible focus areas and solutions:
    - Biomedical devices: imaging equipment, biopsy equipment
    - Bioimaging and Signal processing: screening and diagnostic mammograms, MRI, biopsy microscopy
    - Cellular and Molecular Biotechnology: genomic tests (predict recurrence risk), analyze biopsy samples (detecting proteins associated with cancer), drug development/chemotherapy (herceptin)

<u>For any one of the above scenarios:</u> Compare the two strategies that you outlined. How are they similar? How are they different? Can the strategies be implemented at the same time, or should they be used separately? Why or why not? *Be sure to identify the scenario you're analyzing.*

Answers will vary depending on the focus areas and strategies highlighted. Complete answers compare and contrast strategies. The focus is on getting students to think about how different focus areas can approach the same problem differently and why having multiple focus areas is important (because some solutions are more relevant than others depending on the patient's specific needs). Students should either highlight how the strategies complement each other (illustrating collaboration and interdisciplinarity of BME) or work against each other (illustrating that if two different strategies require access to the same signals or body parts to function, they may disrupt each other). An example of strategies that would complement each other include mammograms to diagnose the cancer and chemotherapy to treat the cancer. An example of strategies that would be used separately include hydrogels embedded with a drug or a pill containing a drug to speed up the healing process: each drug may negatively influence the other, or the drug dose may be too high for the patient if both are administered.