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UNIVERSITY OF GHANA

BSC. ENGINEERING

SECOND SEMESTER EXAMINATIONS: 2016/2017

DEPARTMENT OF BIOMEDICAL ENGINEERING

BMEN 402: TISSUE ENGINEERING AND BIOTECHNOLOGY (3 CREDITS)

INSTRUCTIONS:
PLEASE READ THE PREAMBLE BELOW CAREFULLY AND ATTEMPT ALL QUESTIONS, MAKING SURE YOUR ANSWERS ARE DIRECTLY LINKED TO THE SCENARIO DESCRIBED. PLEASE RESTRICT YOUR ANSWERS TO THE SPACES PROVIDED ON THE QUESTION PAPER AND SHOW ALL CALCULATIONS, WHERE NECESSARY.

TIME ALLOWED: TWO AND HALF (2½) HOURS

A scaffold is to be fabricated for a bone tissue engineering project. Cells are to be seeded on the scaffold material *in vitro* for a period of two weeks after which the scaffold will be implanted into a load bearing bony site (the femur) *in vivo*. The scaffold material is expected to be completely replaced by normal bone tissue 6 months from the start of the project.

A biomaterial with the following properties is chosen to fabricate porous scaffolds for the project:

Density (g/cm^3)	**Young's modulus (GPa)**	**Yield strength (MPa)**	**Rate of mass loss of dense material ($mg/(week.cm^2)$)**
1.6	50	500	30

Each porous scaffold is designed to be cylindrical with a diameter of 1.5 cm and a thickness of 1 cm.

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1. Give three distinct reasons why a scaffold would be needed in this bone tissue engineering project. [9 marks]

a.
b.
c.

2. To promote cell activity, the material is processed into open pore foams with 75% porosity. The pores may be modeled as uniform spheres with diameter of 400 μm.

   a. Estimate the strength and stiffness of the scaffold. [8 marks]

b. Estimate the surface area exposed for degradation for each scaffold, **due to the presence of pores**. [8 marks]

c. Estimate how long it will take, in months, for a porous scaffold to completely degrade. You may assume that each month has 4 weeks. [10 marks]

d. Comment on the suitability of the scaffold for direct implantation into the femur based on your calculations above and knowledge of the mechanical properties of bone.
[5 marks]

3. For the bone tissue engineering project, several cell types are available: osteoblasts, embryonic stem cells, induced pluripotent stem cells (iPSC), synthetic osteoblasts (from a synthetic biology laboratory) and mesenchymal stem cells from adipose tissue.

a. Complete the following table for each of the cell types:

Cell Type	**Major Advantage**	**Major Disadvantage**
Osteoblasts		
Embryonic Stem Cells		
iPSC		
Synthetic Osteoblasts		
Mesenchymal Stem Cells		

[15 marks]

b. Use the analysis in (a) to choose one cell type. Support your choice with **five** strong reasons. [7 marks]

c. What is the Hayflick Limit? [4 marks]

d. With regard to the Hayflick Limit, what specific steps should be taken to ensure that enough cells can be made available for adequate biosynthetic activity? [5 marks]

4. a. Considering the dimensions of the scaffold, give distinct strategies the tissue engineer may use to ensure that the nutritional needs of cells seeded within the scaffold are met during the *in vitro* and *in vivo* phases of the project. [12 marks]

In Vitro Strategy for Cell Nutrition	*In Vivo* Strategy for Cell Nutrition
i.	i.
ii.	ii.
iii.	iii.

b. **Without using chemical regulators**, how may cells in culture be induced to express or maintain the expression of the osteoblastic phenotype? Explain. [8 marks]

5. Briefly explain three different ways in which biotechnology may be applied to the bone tissue engineering project. [9 marks]

a)
b)
c)

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Extra Sheet