

National Exams May 2011

04-Bio-A1, Biomaterials and Biocompatibility

3 hours duration

**NOTES:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.  
Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.  
The first five questions as they appear in the answer book will be marked. As there are 6 questions, please clearly indicate if your preference is for other questions to be marked.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

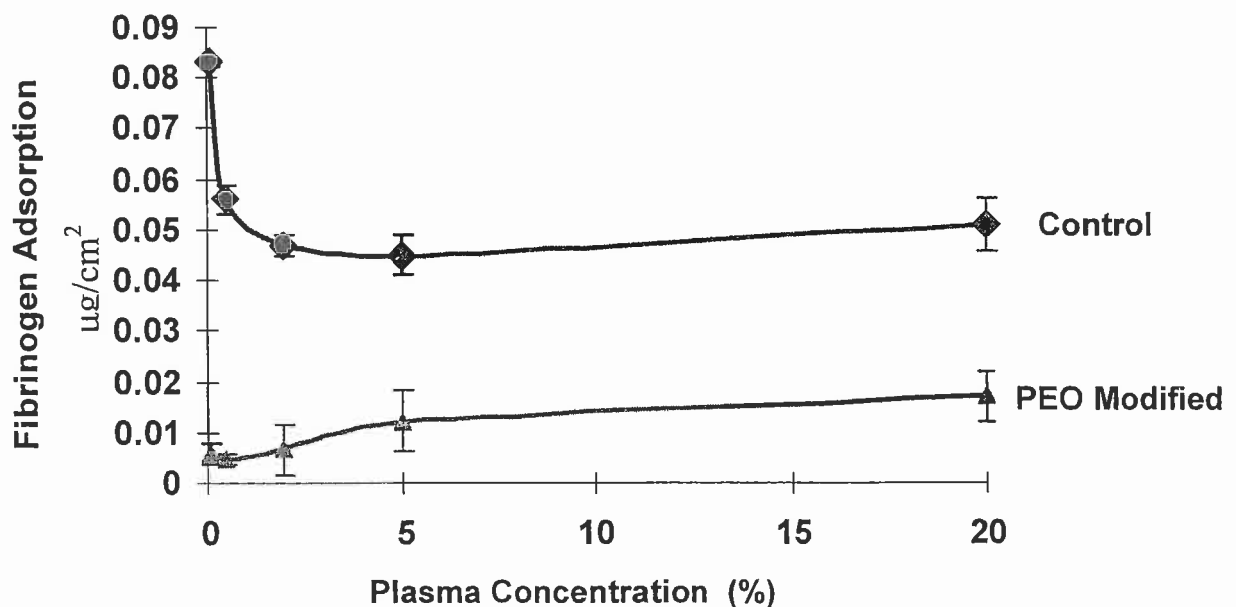
### **Question 1**

Being the VP of Product Development and Acquisition for a large diversified international company, your job is to determine new product potential. This process will lead to the acquisition of any Research and Development firm that has patented a viable novel product process or the identification of any potential in-house developments. Monday morning you open a holographic message sent to you by the VP of Future Business Marketing, which has been sent to the CEO and the Board of Directors. The message details a market study completed on an R&D firm located in Kyoto Japan. Upon further reading, the product in question is a novel “off the shelf” bioengineered liver. Although this is the product, the only technical information provided was that the cell source is embryonic stem cells. Other than that, the message is an endless litany of stock price forecasts, market volatility etc. The conclusion of the message was that your company is seriously interested in acquiring this company, but does not know enough about the technology to determine if the company in question is simply trying to boost its stock value by fabricating rumours of success. Your role is to get the economic people up to speed on the biomaterials aspects of this potentially exciting product.

- a) Document the major technical areas involved in engineering an off the shelf engineering tissue or organ.
- b) Give criteria by which you would assess the “success” of the proposed design.

### Question 2

- Large diameter ( $>6$  mm) vascular grafts made from Dacron or poly (tetrafluoroethylene) (PTFE) have enjoyed significant success for the replacement of diseased or damaged vessels. However, in cases where the vessel to be replaced has a diameter 5 mm or less, the only option for replacement is a patient's native veins. Explain in detail why this is the case, what the challenges are in terms of developing a successful small diameter vascular prosthesis and why you think this goal has yet to be achieved.
- The following results were obtained for the adsorption of fibrinogen from plasma to two different surfaces, a control and a surface modified with polyethylene oxide. Explain the curves and their significance in terms of developing materials with improved blood compatibility.
- It has recently been reported that phospholipids, molecules that mimic the membranes of cells, including red blood cells, can be put onto surfaces with high density and that these surfaces show low levels of protein adsorption. Explain why these surfaces may ultimately show promise in developing more blood compatible biomaterials.



### Question 3:

Hip implants have undergone significant changes since their introduction in both materials and design. These changes have led to the development of more successful biomaterials in orthopedic applications.

- Discuss recent advancements in orthopedic materials engineering and why these changes have been so critical to the success of orthopedic implants.
- Give biological perspectives as to why the current materials are more successful than their predecessors.

**Question 4:**

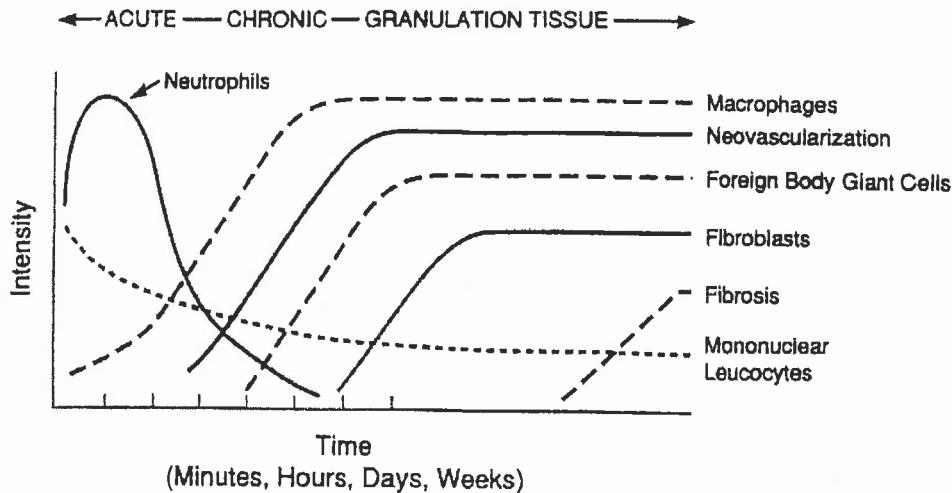
Dental implants are examples of materials that are composites of sometimes very different materials. Implantation can have significant negative effects on the surrounding bone and tissue.

- a) What metals are commonly used in dental implantology and why have these materials been selected?
- b) What are the negative effects generally encountered and how are they minimized?
- c) What are the critical properties for next generation dental materials?

**Question 5:**

Silicone breast implants have been the subject of considerable controversy, including a number of lawsuits. Several women who received silicone breast implants were later diagnosed with various autoimmune disorders.

- a) Given the following figure, what would be the expected interactions between silicone breast implants and the immune system?
- b) Which of these interactions could potentially be related to autoimmunity?

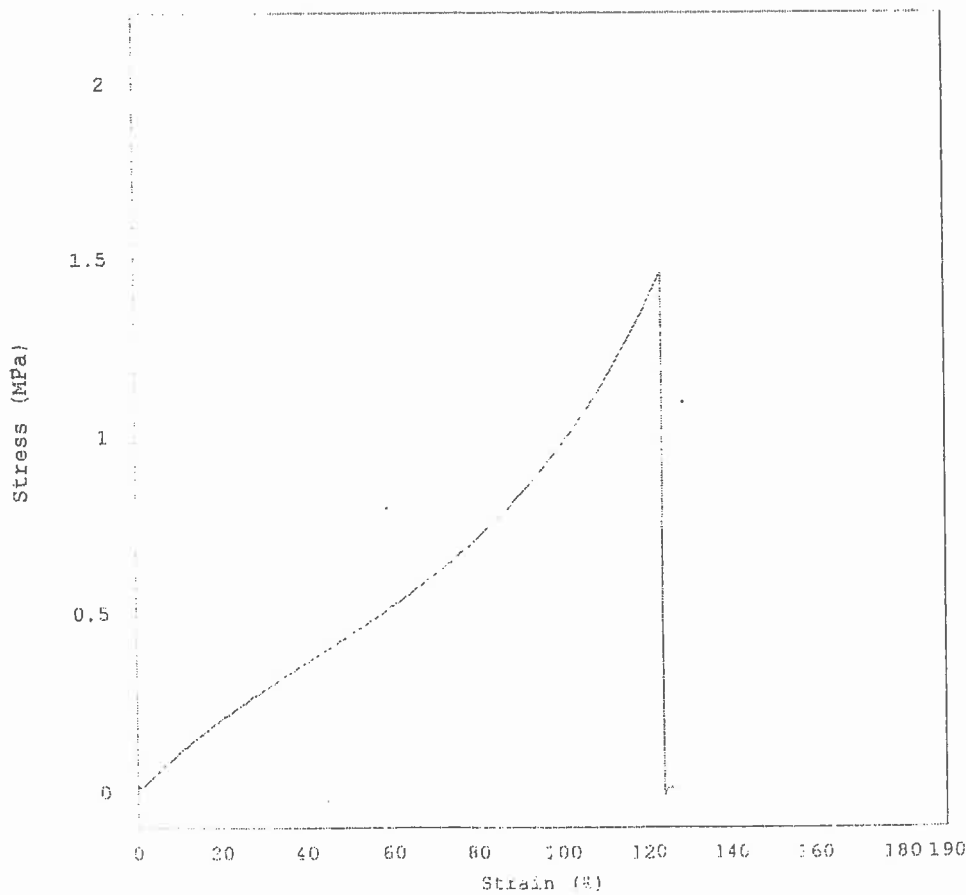


Question 6:

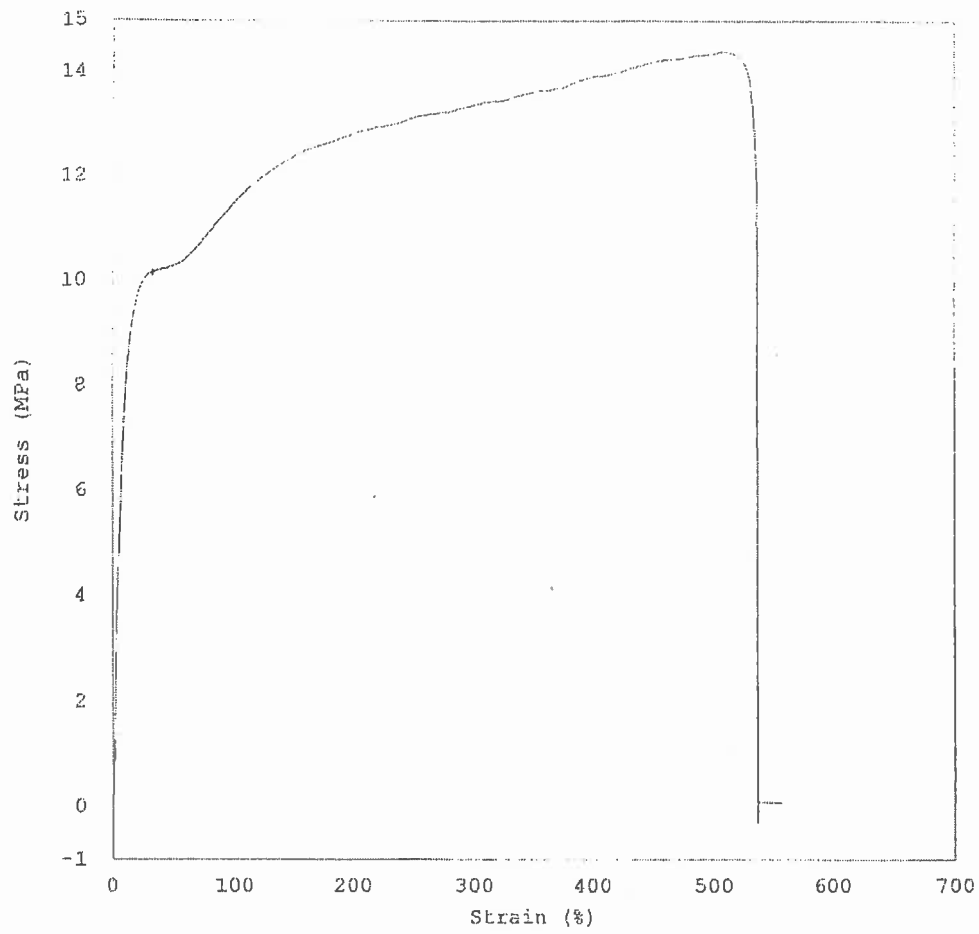
The following two curves were obtained for two proposed biomaterials to be potentially applied in soft tissue applications.

- Describe the differences between the materials and how these properties might be essential for selecting a material.
- Based on these properties, suggest potential applications for these materials. What other properties of the materials would be of interest prior to applying them to these tissues?

	Stress at Max. Load, (MPa)	% Stain at Max Load (%)
Material 1	1.464	61.44
Material 1	1.684	57.5
Material 1	1.671	54.0
Material 2	14.418	506.3
Material 2	13.482	668.8
Material 2	13.5	588.6



**Material 1**



**Material 2**