Tissue Engineering Practice Exam (Sample)

Study Guide

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Questions

1. **Which property is crucial for scaffolds used in load-bearing applications?**
   - A. Degradability
   - B. Elastic modulus
   - C. Surface roughness
   - D. Thermal stability

2. **Porogen leaching can be made out of which of the following?**
   - A. Sodium chloride
   - B. Crystals of saccharose
   - C. Gelatin sphere
   - D. All of the above

3. **Which stem cells can form almost all types of cells in the body, excluding extra-embryonic tissue?**
   - A. Pluripotent stem cells
   - B. Mesenchymal stem cells
   - C. Totipotent stem cells
   - D. Hematopoietic stem cells

4. **Which loading modality was chosen to induce AF-like cells and matrix?**
   - A. 6% strain and 0.1 Hz frequency
   - B. 12% strain and 0.1 Hz frequency
   - C. 6% strain and 1 Hz frequency
   - D. 12% strain and 1 Hz frequency

5. **Which statement correctly describes the S Phase in the eukaryotic cell cycle?**
   - A. The S Phase represents the gap between Mitosis and DNA Synthesis
   - B. Some cells can exit the S Phase in an indefinite period of rest
   - C. The S Phase starts after the G1 Phase and is the time for DNA synthesis
   - D. At the end of the S Phase, the mother cell is ready for division

6. What are the main aims of tendon tissue engineering?

- **A. Decrease energy storage**
- **B. Achieve aligned collagen fibers**
- **C. Restore native biomechanical properties**
- **D. Both aligned fibers and restoration of biomechanical properties**

7. Which is not a use of biodegradable bio-ceramics?

- **A. Drug-delivery devices**
- **B. Repair material for herniated discs**
- **C. Space filling material for areas of bone loss**
- **D. Transfusion tubing**

8. What will regulate the gradual transition from cartilage to tendon structure of annulus fibrosus?

- **A. Surface Chemistry**
- **B. Plasma Modification**
- **C. Mechanical Strain**
- **D. Revascularization**

9. Which statement about EQUicycler is false?

- **A. It induced morphological changes in the cells as they aligned and elongated**
- **B. It was effective in transferring equiaxial mechanical strain**
- **C. It provided a means to apply homogenous equiaxial strain**
- **D. Both b and c**

10. Which type of graft is associated with having no immune rejection?

- **A. Allograft**
- **B. Autograft**
- **C. Xenograft**
- **D. None of the above**

Answers

1. B
2. D
3. A
4. C
5. C
6. D
7. D
8. C
9. D
10. B

Explanations

1. Which property is crucial for scaffolds used in load-bearing applications?

A. Degradability

B. Elastic modulus

C. Surface roughness

D. Thermal stability

In load-bearing applications, the elastic modulus is a critical property for scaffolds because it directly relates to the stiffness and mechanical strength of the material. The elastic modulus indicates how much a material will deform under applied stress, which is vital for scaffolds that must support physiological loads similar to those experienced by natural tissues. In the case of tissues like bone or cartilage, a scaffold with an appropriate elastic modulus will emulate the mechanical properties of the surrounding architecture, promoting proper cellular function and tissue integration. While other properties like degradability, surface roughness, and thermal stability are important in various contexts, they do not primarily address the mechanical demands of load-bearing applications. Degradability, for instance, is more about how the scaffold will break down over time, which is crucial for tissue regeneration but less so for the immediate structural support needed. Surface roughness pertains to cell adhesion and proliferation, which is also important but secondary to the mechanical stability required in load-bearing scenarios. Thermal stability relates to the material's thermal characteristics but does not impact its ability to withstand mechanical loads during use. Thus, in the context of scaffolds required to bear significant loads, the elastic modulus stands out as the most essential property.

2. Porogen leaching can be made out of which of the following?

A. Sodium chloride

B. Crystals of saccharose

C. Gelatin sphere

D. All of the above

Porogen leaching involves the use of porogens—substances that create pores in a material when removed—to form scaffolds with desired porosity in tissue engineering. All the materials listed can serve as effective porogens. Sodium chloride is a commonly used porogen because it is water-soluble and can be easily leached out, leaving behind a porous structure conducive to cell infiltration and nutrient flow. Crystals of saccharose also act as porogens due to their solubility in water, leading to a porous structure after leaching. Their use is particularly beneficial for creating a specific pore size and distribution. Gelatin spheres, which are biodegradable, can also function as porogens, creating pores in a scaffold that can be useful for cellular activities and tissue growth. Their biocompatibility makes them a favorable choice in tissue engineering applications. Using all of these material types underscores the versatility of porogen leaching in scaffold fabrication, enabling researchers to tailor properties according to their specific needs. This is why the inclusion of all options as valid choices highlights the variety of materials that can effectively create porosity within scaffolds through leaching.

3. Which stem cells can form almost all types of cells in the body, excluding extra-embryonic tissue?

A. Pluripotent stem cells

B. Mesenchymal stem cells

C. Totipotent stem cells

D. Hematopoietic stem cells

Pluripotent stem cells possess the unique ability to differentiate into nearly all cell types found in the body, specifically those from the three germ layers: ectoderm, mesoderm, and endoderm. This capacity allows them to give rise to a myriad of tissues and organs, such as muscle, nerve, and blood cells, making them a key component in tissue engineering and regenerative medicine. However, they do not have the capability to develop into extra-embryonic tissues, like the placenta, which is a characteristic of totipotent stem cells. Totipotent stem cells can generate both embryonic and extra-embryonic tissues, but they are limited to the earliest stages of development. Mesenchymal stem cells, while versatile and capable of forming a limited range of specialized tissues like bone, cartilage, and fat, do not have the same expansive differentiation potential as pluripotent stem cells. Hematopoietic stem cells are specifically responsible for generating blood cells and do not have the ability to differentiate into all cell types. Thus, among the options, pluripotent stem cells are the most appropriate choice for their capability to develop into almost all cell types in the body, excluding extra-embryonic tissue.

4. Which loading modality was chosen to induce AF-like cells and matrix?

A. 6% strain and 0.1 Hz frequency

B. 12% strain and 0.1 Hz frequency

C. 6% strain and 1 Hz frequency

D. 12% strain and 1 Hz frequency

The choice of loading modality that involves a 6% strain and a frequency of 1 Hz is effective for inducing atrial fibrillation-like (AF-like) cells and matrix due to the specific mechanical conditions that mimic physiological environments. Strain levels and frequencies play crucial roles in cellular behavior, differentiation, and matrix production in tissue engineering. Using a 6% strain is substantial enough to activate mechanotransductive pathways, stimulating the cells to produce the necessary factors that contribute to the AF-like phenotype. The frequency of 1 Hz is relevant as it closely aligns with the heart's natural beating pattern, making it more biologically relevant for inducing cardiomyocyte-like behavior in engineered tissues. The combination of a moderate strain with a higher frequency provides the right balance that encourages cellular response without overwhelming the cells, fostering an environment conducive to the generation of AF-like characteristics. This loading modality allows for optimal signal transduction while ensuring that the physical environment remains supportive of cell viability and function. In contrast, higher strain levels or lower frequencies could either exceed physiological limits or fail to adequately simulate the dynamic conditions experienced in vivo, which are essential for effectively driving the desired cellular differentiation and matrix deposition.

5. Which statement correctly describes the S Phase in the eukaryotic cell cycle?

- A. The S Phase represents the gap between Mitosis and DNA Synthesis
- B. Some cells can exit the S Phase in an indefinite period of rest
- C. The S Phase starts after the G1 Phase and is the time for DNA synthesis
- D. At the end of the S Phase, the mother cell is ready for division

The S Phase, or Synthesis Phase, is a crucial part of the eukaryotic cell cycle where DNA replication occurs. This phase follows the G1 Phase, which is the first gap phase focused on cell growth and preparation for DNA synthesis. During the S Phase, each chromosome is replicated to produce sister chromatids, effectively doubling the genetic material in the cell. By the end of this phase, the cell has two copies of each chromosome, which sets the stage for subsequent cell division. This understanding clarifies why the statement about the S Phase starting after the G1 Phase and being the time dedicated to DNA synthesis is the correct option. The accurate sequencing of the cell cycle phases is fundamental to grasping how cells prepare for division and ensure genetic continuity in daughter cells. Additionally, the context surrounding the other choices provides further clarity on the subject. For instance, while some cells can exit the cell cycle and enter a resting state, this primarily pertains to G0 Phase rather than S Phase itself. Therefore, emphasizing the correct sequencing and function during the S Phase is critical in understanding cell cycle dynamics.

6. What are the main aims of tendon tissue engineering?

- A. Decrease energy storage
- B. Achieve aligned collagen fibers
- C. Restore native biomechanical properties
- D. Both aligned fibers and restoration of biomechanical properties

The main aims of tendon tissue engineering are centered around two critical aspects: achieving aligned collagen fibers and restoring the native biomechanical properties of tendons. Tendons possess a unique structure characterized by a highly organized arrangement of collagen fibers that contribute to their ability to handle high tensile loads. When tendon tissue is engineered, it is essential to replicate this alignment of collagen fibers to ensure that the engineered tissue can effectively transmit forces similar to native tendons. Aligned collagen fibers help in maintaining the structural integrity and function of the tendon, allowing it to perform its role in connecting muscles to bones efficiently. In addition to fiber alignment, restoring the native biomechanical properties is crucial for the tendon to behave as it would naturally. This means that the engineered tissue should not only look similar to real tendon tissue but also have similar mechanical strength, elasticity, and response to loading conditions. Achieving these aims ensures that the engineered tendon can withstand dynamic movements and mechanical stresses faced during activities. Therefore, the combined goals of achieving aligned fibers and restoring native biomechanical properties are fundamental in the development of effective tendon tissue engineering strategies. This comprehensive approach is vital for creating functional tissue that can support healing and restore mobility in patients with tendon injuries.

7. Which is not a use of biodegradable bio-ceramics?

A. Drug-delivery devices

B. Repair material for herniated discs

C. Space filling material for areas of bone loss

D. Transfusion tubing

Biodegradable bio-ceramics are materials that can be used in various medical applications due to their ability to mimic natural bone properties and gradually degrade over time within the body. Their primary uses often involve applications directly related to bone repair and tissue engineering. Drug-delivery devices utilize biodegradable materials to release therapeutic agents in a controlled manner over time. Repairing materials for herniated discs is another application, as bio-ceramics can help in regenerating or stabilizing the spine. Additionally, space-filling materials for areas of bone loss leverage the osteoconductive properties of bio-ceramics, which help facilitate new bone growth. In contrast, transfusion tubing is primarily designed for pathways to transport blood or fluids in a clinical setting and requires materials that are not biodegradable to maintain integrity and safety over time. Therefore, this option does not align with the typical uses of biodegradable bio-ceramics, making it the correct choice.

8. What will regulate the gradual transition from cartilage to tendon structure of annulus fibrosus?

A. Surface Chemistry

B. Plasma Modification

C. Mechanical Strain

D. Revascularization

The gradual transition from cartilage to tendon structure in the annulus fibrosus is primarily regulated by mechanical strain. The annulus fibrosus, which is the outer part of the intervertebral disc, experiences varying mechanical loads in response to movement and external forces. These mechanical strains stimulate cellular responses that influence the biochemical and structural properties of the annulus fibrosus. Specifically, the mechanisms under mechanical strain can affect factors such as extracellular matrix production, cellular differentiation, and tissue remodeling. The cells within the annulus fibrosus, primarily chondrocytes and fibroblasts, will respond to different levels of mechanical stress by producing different types of extracellular matrix components that align with the functional needs of the tissue. For example, higher strains may promote a more fibrous and tendon-like structure, while lower strains may encourage the maintenance or production of cartilage-like properties. In contrast, surface chemistry typically affects cell adhesion and signaling but does not directly govern the mechanical loading transitions that are crucial for structural changes in the annulus fibrosus. Plasma modification may enhance biocompatibility or alter surface characteristics but is not directly involved in the mechanical regulation of tissue structure. Revascularization, which involves the formation of new blood vessels, is more related to

9. Which statement about EQUicycler is false?

A. It induced morphological changes in the cells as they aligned and elongated

B. It was effective in transferring equiaxial mechanical strain

C. It provided a means to apply homogenous equiaxial strain

D. Both b and c

The EQUicycler is a specialized device used in tissue engineering to apply mechanical strain to cell cultures, simulating the conditions they would experience in vivo. Analyzing the claims, the statements regarding its capacity to transfer equiaxial mechanical strain (B) and provide a means to apply homogenous equiaxial strain (C) are both accurate representations of its functionality. The EQUicycler is indeed designed to apply equiaxial strain uniformly across the sample, which helps in studying the effects of mechanical stimulation on cell behavior and tissue development. Therefore, both B and C reflect true characteristics of the EQUicycler. Looking at statement A, while it is true that the device induces morphological changes in cells due to the mechanical forces applied, it doesn't negate the validity of statements B and C. The essence of understanding from this question centers on identifying the statements related to the EQUicycler's mechanical capabilities, which are accurately represented in the true nature of its functions. Thus, stating that both B and C are false is not correct, as they accurately describe the operational principles of the EQUicycler.

10. Which type of graft is associated with having no immune rejection?

A. Allograft

B. Autograft

C. Xenograft

D. None of the above

An autograft is associated with having no immune rejection because it involves transplanting tissue from one site to another within the same individual. Since the graft originates from the patient's own body, the immune system recognizes the tissue as "self," eliminating the risk of an immune response that could lead to rejection. This characteristic makes autografts particularly advantageous in tissue engineering and surgical procedures, as they promote better healing and integration compared to grafts that originate from a different individual or species. In contrast, allografts (tissue from a donor of the same species) and xenografts (tissue from a different species) are more susceptible to immune rejection because the recipient's immune system may identify these tissues as foreign. Hence, even though techniques exist to mitigate rejection, the potential for immune response remains a significant consideration in those graft types.