Challenge based learning (CBL)

A polymer patch to repair the contractile function in the infarcted heart

**Note for teachers: A CBL user guide can be found at** www.jandeboerlab.com/TissueEngineering with instructions and tips to run an effective CBL teaching session.

**Background and vision**

Myocardial infarction (MI) is a high incidence disease worldwide. MI is the result of coronary obstruction and loss of blood flow to the cardiac tissue. Since clinical and surgical procedures cannot readily repair the fibrotic tissue, MI can lead to permanent tissue damage due to ischemia and loss of electrical conduction across the infarcted cardiac tissue. The long-term goal of this research is to generate materials to be deployed non-invasively that can readily restore electrical conduction and contractile force in the heart.

**Motivation and stakeholders**

The design space of polymers is enormous and polymer chemistry has yielded many interesting products. For instance, polymer chemistry can be tuned such that some materials can transduce electrical signals and others can show very high adhesive properties in watery conditions. Injectable and in situ gelling materials have been produced as well. Therefore, the state-of-art knowledge in material science and biomaterials can offer opportunities to generate conductive, adhesive and injectable polymers with intended uses in MI. Solutions to mitigate this problem should consider the needs, requirements and regulatory, financial and technical boundary conditions defined by stakeholders such as patients in risk to suffer MI, cardiothoracic surgeons, cardiologists and biomaterial engineers.

**Problem definition**

No single polymer formulation exists that combines all the requirements stated above to produce patches that conduce electrical signals across cardiac infarcts. There is a need to generate materials that are contractile, conductive, adhesive in watery conditions, as well as injectable to resolve the fibrotic, and often necrotic, cardiac patch after MI. This material should also facilitate the invasion and population of native cardiomyocytes to guide cell-material interactions towards the healing and regenerative route.

**Challenge**

To develop an injectable scaffold with conductive and adhesive capacities to provide a contractile and biocompatible bridge between the damaged myocardium and the healthy cardiac surroundings following MI.

**Learning framework**

Reading the Cell-Material Interaction and Principles of Cardiovascular Tissue Engineering chapters, and additional relevant literature will help you to understand:

1. The basic characteristics of a biomaterial when used as a scaffold for tissue regeneration.
2. The mechanisms of electrical conduction in the heart.
3. The ideal properties of a biomaterial used for myocardium regeneration.
4. The characteristics of hydrogels and their potential application in tissue regeneration strategies.

For a more focused examination of the challenge, create one mind map to include information about the following:

1. The challenges in designing a biomaterial appropriate for cell therapy in MI
2. The characteristics of conductive polymers and their potential to be used as biomaterials following MI.
3. The capacity of a conductive polymer to impact cardiomyocyte differentiation, specifically, in terms of electrophysiology and electrical signal transduction in the heart.
4. The challenges associated with designing biomaterials using conductive polymers.

**End product**

A three-minute video explaining the solution of your challenge. Please include your motivation and the steps to execute your solution. More information and examples of CBL videos can be found in the student guide at www.jandeboerlab.com/TissueEngineering.

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