Challenge based learning (CBL)

Temporal control of scaffold degradation for allogenic islet transplantation

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

Type-I diabetes (T-ID) is an autoimmune disease caused by the selective destruction of pancreatic insulin-producing beta cells, which results in uncontrolled hyperglycemia and hypoinsulinemia. Worldwide, 1 in every 500 people under the age of 19 suffer from type-I diabetes. Insulin therapy helps to manage the disease by keeping the insulin levels in acceptable range, but it is not a long-lasting cure. Therefore, there is a need to generate tissue-engineered beta cells and functional islets of Langerhans and to make them clinically available to treat Type 1 diabetes. The long-term goal of this research field is to use allogeneic islets of Langerhans that can respond to postprandial glycemic levels and replace the function of the pancreas.

Motivation and stakeholders

Allogeneic islets can be transplanted in ectopic sites of the diabetic patient's body. To protect the transplanted cells from the host immune system, the islets are encapsulated in inert biomaterials. Still, allogeneic islands have a limited lifespan, and it is desirable that non-functional islands are cleared by the body. The same is true for the materials that encapsulate them. Solutions to address this problem should consider the needs, requirements and regulatory, financial and technical boundary conditions defined by stakeholders such as patients with type-I diabetes, internal medicine doctors, cell biologists, biofabrication specialists, and biomaterial engineers.

Problem definition

Allogeneic island transplantation is a promising cell-based therapy for Type 1 Diabetes. However, allogenic rejection is preventing this strategy to be widely used in the clinic. To overcome allogenic rejection, a novel biodegradable scaffold which protects the islets from the immune system , should be developed. The biodegradable scaffold should degrade when the islet cells are not functional anymore. To do so, an inducible degradation-based switch (biosensor) should be developed. In summary the islet cells should be maintained functionally during their lifespan and an inducible biosensor system should initiate the degradation to clear the remaining scaffold before implanting the new one.

Challenge

To design a non-cytotoxic (biocompatible), polymer scaffold to be used safely and effectively to treat type 1 diabetes for allogenic islet transplants.

Learning framework

Reading the Degradation of Biomaterials and Synthetic Biomaterials chapters and related literature will help you to understand:

1. What is a hydrogel.
2. The basic concepts of biomaterials degradation
3. The state of the art of allogeneic island transplantation.

For a more focused examination of the challenge, read scientific literature and create a mind map to include information about the following:

4. Strategies used in the body to control extracellular matrix degradation.
5. Molecular processes which are different between functional and non-functional islets of Langerhans.
6. Biomaterial engineering strategies to manipulate the degradation properties of a hydrogel.
7. The biochemical and molecular building blocks to engineer the degradation properties of hydrogels.

End product

A three-minute video explaining the solution of your challenge. Please include your motivation and the steps to execute your solution.