

Challenge based learning (CBL)

Engineering hair follicles in tissue engineered skin

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

Tissue-engineered skin (TES) is a useful and effective product for wound repair and regeneration. The first-documented bioengineered skin product appeared 30 years ago as cultured epithelial autografts and has been used successfully since to treat major burns and other skin wounds. Even though TES substitutes are being widely used, there is room for improvement. Ideally, a TES product should completely replicate the normal physiology and function of skin including appropriate mechanical properties, presence of hair follicles with normal hair growth cycle, sweat glands and nerves. It should integrate with the host tissue with negligible scarring and induce minimal inflammation at the graft site. The long term vision is to generate tissue-engineered skin with all the appendages that can be encountered in the human counterpart.

Motivation and stakeholders

Skin appendages (hair follicles, sebaceous and sweat glands) and nerves are important constituents for fully functional skin. Many cell types that constitute skin appendages can be produced using stem cells. The functionality of these appendages has been demonstrated in vitro and in vivo. Solutions to produce functional TES products including appendages should consider the needs, requirements and regulatory, financial and technical boundary conditions defined by stakeholders such as patients with skin burns, dermatologists, and biomaterial engineers.

Problem definition

Even though hair follicles have been successfully generated in the lab using mouse models, effective implementation as a treatment option is still not possible in man due to several technical hurdles. First, the technical complexity in isolating relevant cell types. Second, the difficulty to co-culture different cell types in the correct spatial organization while maintaining their specialized phenotypes. And finally, difficulty in maintaining cycles of growth and rest in engineered hair follicles due to inability of the transplanted cells to regain their fully differentiated potential.

Challenge

The goal of this CBL module is to design a novel strategy to overcome one of the challenges defined in the problem definition.

Learning framework

Reading of the Skin Tissue Engineering chapter and related literature will help you to understand

1. The function of the skin and its appendages.
2. The stages of hair growth.
3. Cell types needed to engineer hair follicles.
4. Cellular signals (both mechanical and chemical) needed to generate hair follicles during embryonic development.

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

5. Biomaterials suitable for generation of tissue engineered skin.
6. Current strategies to engineer human TES with hair follicles
7. Steps involved in the reconstruction of hair follicle in TES substitutes.
8. Cytokines and cell secretions needed to stimulate hair follicle growth in TES substitute.

End product

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

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