Challenge based learning (CBL)
Establishing a machine learning model for peptide-induced cardiomyocyte maturation

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
Biomaterials are widely used as scaffolds in tissue engineering and to produce medical implants. The response to implanted biomaterials by the body is often not optimal and can lead to infection, encapsulation, and can result in poor differentiation of stem cells that attach to them. It is well documented that the physicochemical properties of biomaterials determine the cellular response and their modifications can optimize cell-material interaction. Combinatorial chemistry allows us to produce hundreds to thousands of different polymers and high throughput screening can identify the most appropriate hit for a particular biological or biomedical applications. Furthermore, high throughput screening can be used to generate quantitative structure activity relationship (QSAR) models which are key for further biomaterial optimization. The long-term vision of this research is that in-depth knowledge of material properties and cellular response to many different materials will lead the way in bioactive material discovery.

Motivation and stakeholders
Induced-pluripotent stem cells (iPSCs) can be differentiated into cardiomyocytes and are seen as potential source for the generation of cardiac patches to repair tissue after an infarct. However, cardiomyocyte differentiation is not yet fully achieved, with current protocols showing that the cells are still in an immature stage. Polymers are used to grow patches of IPSC-derived cardiomyocytes and this field can be boosted if biomaterial engineers are able to model the relationship between polymer properties and cardiomyocyte maturation. Solutions to mitigate this problem should consider the needs, requirements and regulatory, financial and technical boundary conditions defined by stakeholders such as cell biologists, material scientists, computational biologists, bioengineers, and surgeons (orthopedic, plastic/reconstructive, and cardiothoracic).

Problem definition
Polymer backbones can be modified with peptides in order to functionalize them with an application in mind. Peptides are chemically very diverse and will lead to a wide diversity of biological activity. So far, no libraries of peptide-modified polymers exist, the polymer material properties have not yet been defined and the cell response still needs to be monitored. Thus, using cardiomyocyte maturation as an example, there is a need to create a HTS platform to model and study biomaterial libraries and its impact on cell-material interactions.

Challenge
To design a HTS platform to analyze cellular and physicochemical properties of a polymer to which a library of peptides is added, arrayed and in which cell response and material properties can be measured and modeled.

Learning framework
Reading the Biomaterial discovery chapter and related literature will help you to understand:
1. The ways to prepare polymer libraries.
2. The methods and techniques to measure biomaterial properties.
3. The ways to measure biological readouts in polymer libraries.
4. The modelling methods to describe the quantitative structure activity relationship (QSAR) of materials to cell response.

For a more focused examination of the challenge, read scientific literature and create a mind map to include information about the following:
5. The methods to produce peptides and how they can be attached to a polymer backbone.
6. The types of polymers used so far to optimize cardiomyocyte maturation.
7. The cardiomyocyte differentiation stages and which markers are used to identify them.
8. The ways Design of Experiments (DoE) can assist scientists and bioengineers in designing experiments.

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