# Challenge based learning (CBL)

# In situ repair of large ventricular septum defects

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

**Background and vision**

Embryologic development of the heart is complete at 8 weeks of gestation, but many congenital heart problems such as the ventricular septum defect (VSD) can arise. Surgery to correct major VSD is done in utero or after birth. However, there is a clinical need to develop minimally-invasive surgery to introduce new materials to correct septal defects in the heart. The long-term vision is to develop non-invasive surgery to solve VSD with smart materials that can readily attach to the beating heart and withstand the high mechanical loads in the beating heart, without detrimental effects to the fetus in the womb.

**Motivation and stakeholders**

Heart septa’s function is to divide atria and ventricles in two distinct chambers and prevent blood flow between them. Atria and ventricle septa consist of an internal myocardium layer sandwiched between two endocardium layers. Currently, large septal (wall) defects can only be solved using invasive surgery after birth but non-invasive, catheter-based techniques are being optimized to deliver biomaterials via major blood vessels to the heart. To strengthen these techniques, rapid prototyping is capable to produce custom-designed scaffolds for a diverse array of biomedical applications. Thus, the potential exists to design a new family of VSD scaffolds to successfully respond to the dynamic environment of the beating heart. Solutions to mitigate VSD should consider the needs, requirements and regulatory, financial and technical boundary conditions defined by stakeholders such as pediatric cardiac surgeons, neonatologists, pediatric nurses, material scientists and biofabrication engineers.

**Problem definition**

Current rapid prototyping strategies mainly rely on a layer-by-layer approach to generate scaffolds. So far, no scaffolds have been fabricated to mimic the triple layer in native ventricle septum and with mechanical properties robust enough to withstand contraction and relaxation. Additionally, for VSD, the scaffold should be delivered non-invasively and with the capacity to tightly attach to the ventricle wall.

**Challenge**

To create a new volumetric additive manufacturing technique that can generate adequate scaffolds for large VSD.

**Learning framework**

Reading the Scaffold Design and the Cardiovascular Tissue Engineering chapters will help you to understand:

1. The tissue architecture of the heart and especially of the septum.
2. Phenotype of the endo- and myocardial cells.
3. The tissue defects observed in VSD.
4. Current surgical approaches to treat VSD.
5. The mechanical compliance of scaffolds used in cardiovascular engineering.
6. The maintenance of endo- and myocardial phenotype of cells in contact with scaffolds.

For a more detailed look into your challenge, prepare a mind map summarizing:

1. Scaffold biofabrication techniques: from layer-by-layer manufacturing to volumetric additive manufacturing.
2. Biomaterials used for cardiac tissue engineering.
3. Mechanical requirements of biomaterials in cardiac tissue engineering.
4. Methods to deliver materials in situ.

**End product**

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

# © Jan de Boer. CBL available for classroom use and CBL videos and can be found at www.jandeboerlab.com/TissueEngineering.