

# Scaffolds in tissue engineering

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## What are scaffolds in tissue engineering?

Tissue engineering along with regenerative medicine can be used to create 'Scaffolds' in the human body. These scaffolds are used to support organs and organ systems that may have been damaged after injury or disease. So what is tissue engineering? 'Tissue engineering is the use of a combination of cells, engineering and materials methods, and suitable biochemical and physico-chemical factors to improve or replace biological functions'. This is most commonly achieved through the use of stem cells. Stem cells are unique types of cells that are undifferentiated. So the main focus of creating these constructs is to be able to safely deliver these stem cells, and create a structure that is physically and mechanically stable so that these stem cells can differentiate.

Scaffolds are of great importance in clinical medicine. It is an upcoming field, and usually associated with conditions involving organ disease or failure. It is used to rebuild organs and return normal function.

### Requirements scaffolds must fulfil in their purpose

- Allow cell attachment and migration
- Deliver and retain cells and biochemical factors
- Enable diffusion of vital cell nutrients and expressed products
- Exert certain mechanical and biological influences to modify the behaviour of the cell phase

There are two main types of ways scaffolds in tissue engineering can be achieved.

### Injectable tissue engineering

Injectable tissue engineering can be used as an invasive procedure that involves injecting stem cells with a biomaterial into an organ such as the Heart that can form a gel in-situ. A gel in-situ is a soluble liquid which contains the stem cells and various biomaterials, once injected into the body, it will solidify and form a gel that acts as a scaffold to keep the structure of the organ in place. The stem cells will then differentiate into the required cells (mostly muscle cells such as myocardium), and replace the muscle tissue that had been destroyed previously due to any diseases etc. There are various different biomaterials that can be injected into organs in the body; each one has certain advantages and disadvantages. These biomaterials include: Fibrin, Alginate, Matrigel, Collagen and Chitosan. Biomaterials that are injected do not have to carry stem cells. They may be injected with other chemical components that show improvements in organ function post - injection.

### Engineered constructs using invasive techniques

Fundamentally, this process involves the in vitro construction of a patch (or a graft). This patch is made from a combination of stem cells and an artificial extracellular matrix (biomaterial). The engineered patch can then be surgically implanted into affected areas of the body that need reconstruction. This procedure is very controversial in terms of ethics and also patient satisfaction. This is mainly because this technique is very invasive compared to other techniques that can be used alternatively. However, it does have many advantages. Firstly, the cells are all distributed evenly across the matrix. This ensures that stem cell clusters are not formed. Secondly, differentiation of these stem cells can take place in vitro. This is convenient because the differentiation occurs in a controlled environment. This ensures that stem cells aren't wasted, and also that there are no mistakes in the differentiation process. For example, red blood cells being formed instead of cardiomyocytes.

### Controlling biodegradation and porosity of scaffolds

Over time scaffolds in the human body must degrade. They must remain in the organ until all the cells that are delivered become fully integrated. However, they should not linger long enough so that they hinder organ function. A simple solution to this is biodegradability. If the biomaterial used can degrade, then it satisfies all the above necessities a biomaterial should fulfil.

There are many different ways scaffolds can be made so that they have a porous structure. These include:

- Nanofiber Self-Assembly
- Textile technologies
- Solvent Casting & Particulate Leaching (SCPL)
- Gas Foaming
- Emulsification/Freeze-drying
- Thermally Induced Phase Separation (TIPS)
- Electrospinning
- CAD/CAM Technologies

## **Future developments for scaffolds**

Short-term goals for scaffolds:

• Scaffold success should be standardised using these criteria – (1) quantitate scaffold cell survival, (2) ascertain the differentiated status of successfully engrafted cells, (3) assess donor/host electromechanical coupling, and (4) determine if scaffold have a beneficial impact on organ function.

• Investigation should take place to find out the perfect time to implant these scaffolds after an organ failure, and also the quantity of stem cells used in a scaffold should be standardized according to the severity of damage to the organ. If this is achieved, this type of treatment will occur more swiftly in individuals who are in need of organ reconstruction using tissue engineering.

Long-term goals for scaffolds:

• Establish to what effect these scaffolds actually contribute to organ function, in comparison to the effects it has on the actual infarct/affected area itself (E.g. effect on infarct size).

• Establish what other organ diseases could be treated with success using this procedure.

• Investigate the pros and cons of different types of donor cells used to engineer these grafts.

• Reinforce this cell delivery mechanism by investigating and using techniques to enhance cell survival in the scaffold.

3D printing of scaffolds

## **Bibliography**

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