DOCTORAL THESIS

“From spider silk to tissues”

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From spider silk to artificial tissues

Vanessa J. Neubauer is an alumnus of the Elite Graduate Program "Macromolecular Science" at the University of Bayreuth. In her PhD studies, she develops scaffolds for regenerative medicine, based on proteins inspired by spider silk.

Spider silk proteins as highly suitable biomaterial

A continuing shortage of donor organs and tissues is among others the challenges of modern medicine. In a so-called tissue engineering approach, scientists focus on the development of artificial tissues. These tissues are based on a blueprint of natural tissues, which has to be replaced. In this context, constructs can be tailored for the individual patient.

Vanessa J. Neubauer works in a cooperation project, which aims at the fabrication of tendon replacement scaffolds. While displaying features such as a gradient structure, mineral components and tissue distinct cells, similar properties as the natural tendon are to be achieved.

As the silk causes no immune reaction in the body, spider webs were already used in ancient times to cover wounds. Further, spider silk fibers are highly elastic and tough resulting in an even better performance than the toughest man-made fibers as Kevlar and Nylon. Recently, the research group of Prof. Thomas Scheibel at the University of Bayreuth engineered new types of proteins inspired by spider silk. For this reason, the encoded genetic information of the European garden cross spider's dragline silk was successfully modified. Then, the proteins can be produced in powdery form via a large-scale fermentation process in bacteria and used e.g. for biomedical applications in the body.

Biofabrication of spider silk scaffolds

For the design and biofabrication of tissue engineering constructs, several aspects have to be considered. The scaffold must be compatible with and fit into the complex environment in the body. Furthermore, it has to degrade at the same speed as the surrounding tissue is recovering during the healing process. In case of the tendon, the mechanical properties also play an important role. It is a high load bearing tissue, which connects the muscle to the bone. To transmit motion from the contracted skeleton muscle to the bone, a gradual transition of soft to hard tissue is required. For example at the connecting site to the bone, a gradual increase in minerals leads to a seamless transition. This gradient structure then serves a linear load transmission and avoids crack propagation.

Vanessa J. Neubauer and co-workers develop gradient constructs for biomedical applications. These constructs can be obtained by various processing methods from spider silk proteins and result in fibers, foams, films or soft hydrogels. Hydrogels contain a high amount of water and are commonly used for 3D (bio)printing. They can serve as a suitable environment for cells. When cells are encapsulated in hydrogels as so-called cell loaded "bioinks", "living constructs" are generated during printing.

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