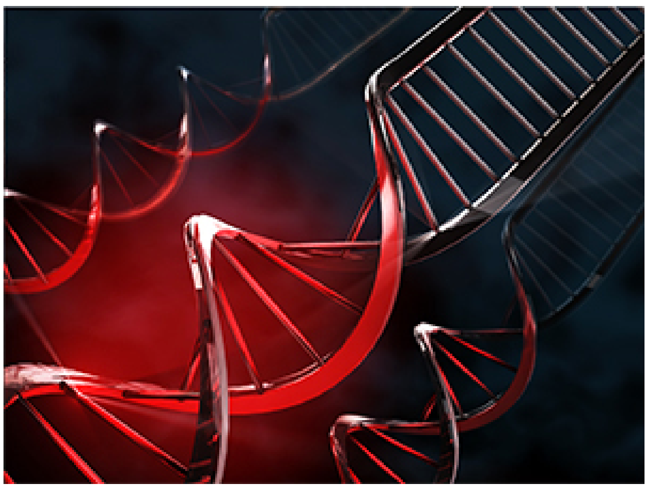
3-D printing and origami techniques combined in development of self-folding medical implants

October 21 2016



Credit: Delft University of Technology

Researchers at TU Delft have made flat surfaces that are 3-D printed and then 'taught' how to self- fold later. The materials are potentially very well suited for all kinds of medical implants. They report on their findings in the October 24th edition of Materials Horizons which features this research on its cover.

Holy grail

Complete regeneration of functional tissues is the holy grail of tissue engineering and could revolutionise treatment of many diseases. Effective tissue regeneration often calls for multifunctional biomaterials. A lot of research is currently going in that field. One example is the large research project, led by Maastricht UMC and with TU Delft as one of the participants, in the field of 'smart' 3-D printed implants for recovery of bone defects. The project started this month; if it's successful, it will lead to faster recovery of patients and less operations.

Surface

But the potential applications of 3-D printed bio-implants is much bigger than only bone defects. Dr. Amir Zadpoor is one of the researchers at TU Delft in this field. He cooperates closely with hospitals like LUMC, UMC and AMC.

'Ideally, biomaterials should be optimised not only in terms of their 3-D structure but also in terms of their surface nano-patterns', says Zadpoor. '3-D printing enables us to create very complex 3-D structures, but the access to the surface is very limited during the 3-D printing process. Nanolithography techniques enable generation of very complex surface nano-patterns but generally only on flat surfaces. There was no way of combining arbitrarily complex 3-D structures with arbitrarily complex surface nano-patterns.'

Origami

Zadpoor looks to the ancient Japanese art of paper folding (origami) to solve this deadlock. In this approach, flat surfaces are first 3-D printed in a particular way to teach them how to self-fold. The flat surface is then decorated with complex nano-patterns. Finally, the self-folding mechanism is activated (for instance by a change in temperature) to enable folding of the flat sheet and the formation of complex 3-D structures.

Zadpoor: "Nature uses various activation mechanisms to program complex transformations in the shape and functionality of living organisms. Inspired by such natural events, our team, including researchers S. Janbaz and R. Hedayati, developed initially flat (two-dimensional) programmable materials that, when triggered by a stimulus such as temperature, could self-transform their shape into a complex three-dimensional geometry".

Shape shifting

'We used different arrangements of bi- and multi-layers of a shape memory polymer (SMP) and hyperelastic polymers to program four basic modes of shape-shifting including self-rolling, self-twisting (self-helixing), combined self-rolling and self-wrinkling, and wave-like strips.' Some of the modes of shape-shifting were then integrated into other two-dimensional constructs to obtain self-twisting DNA-inspired structures, programmed pattern development in cellular solids, self-folding origami, and self-organizing fibers.

'This work is just one little step towards better medical implants', says Zadpoor, 'but we are definitely making exciting progress.'

More information: Programming the shape-shifting of flat soft matter: from self-rolling/self-twisting materials to self-folding origami DOI: 10.1039/C6MH00195E

Provided by Delft University of Technology origami-techniques-combined-self-folding.html