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Tanja Weil: solutions involving biohybrid materials

Tanja Weil travelled across half the globe in order to be able to start her new position as the head of the Institute of Organic Chemistry III (Macromolecular Chemistry and Organic Materials) at the University of Ulm on 1 May 2010. Prior to her current position, the 36-year-old chemist was associate professor at the renowned National University of Singapore and is now trying to bridge her discipline with the disciplines of biology, medicine and the materials sciences with research on biohybrid molecules.

These hybrid materials combine artificial constituents such as dendrimers, nanotubes and polymers with natural constituents such as proteins, amino acids and peptides. Such complex, synthesised macromolecules are not an end in itself, and are not academic l'art pour l'art. Although the synthesis of such molecules requires a great deal of basic research, intuition and creativity still need to be combined with thorough knowledge in organic and polymer chemistry, explains Tanja Weil. The hybrid materials are made to measure and are an answer to user problems such as the targeted transport of pharmaceutically active substances into human cells.

Tanja Weil's CV clearly shows why the new director of the Ulm-based Institute of Organic Chemistry mentions basic research and application in the same breath. Prior to her new position in Ulm, Weil worked in two different worlds, i.e. in academia and industry, and sometimes she even worked in the two areas simultaneously, which was quite a stressful occupation to say the least.

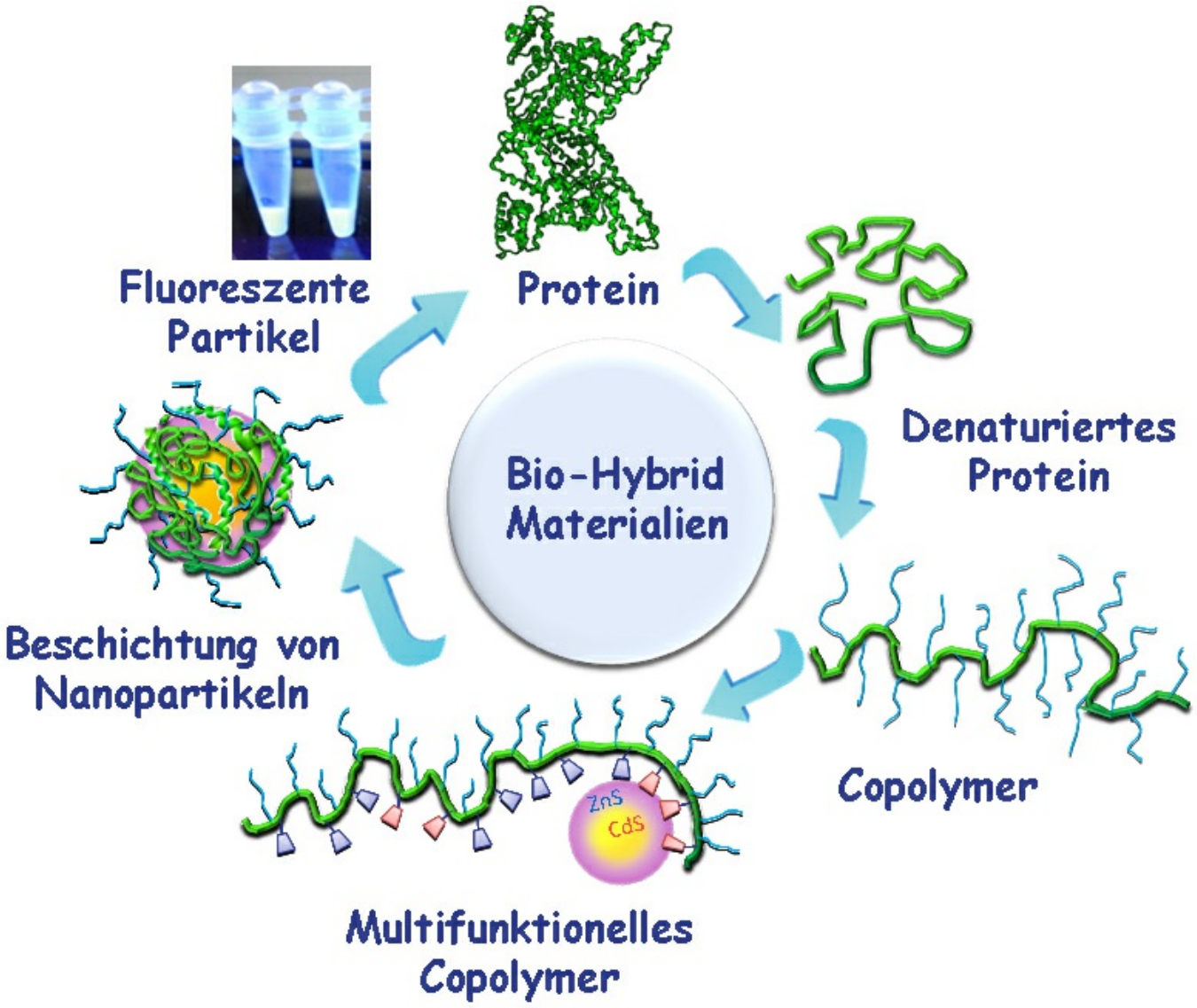
Knows two worlds inside out

Following her chemistry studies in Braunschweig and Bordeaux, Tanja Weil completed her doctoral thesis on biologically inspired polyphenyl dendrimers at the Mainz-based Max Planck Institute under the supervision of Professor Klaus Muellen, for which she also received a research prize. After a short stay in the USA, she accepted an offer from Merz Pharmaceuticals in 2002, where she focused on Alzheimer's disease research.

At Merz Pharmaceuticals, Weil was asked to establish a research group and to carry out what she was most enthusiastic about - the discovery, development and identification of the molecular mechanisms of action of a biologically active substance. This was exactly the field that is generally described as 'medical chemistry' in chemistry encyclopaedias. In addition, the young researcher did not have to deal with the acquisition of third-party funds, something that is common in academic settings. Weil was soon appointed head of Merz's Department of Medical Chemistry and Drug Design. However, in 2005 she was thinking about the possibility of returning to the academic world.

Prof. Tanja Weil has recently joined the Faculty of Chemistry at the University of Ulm

Novel materials on the basis of proteins

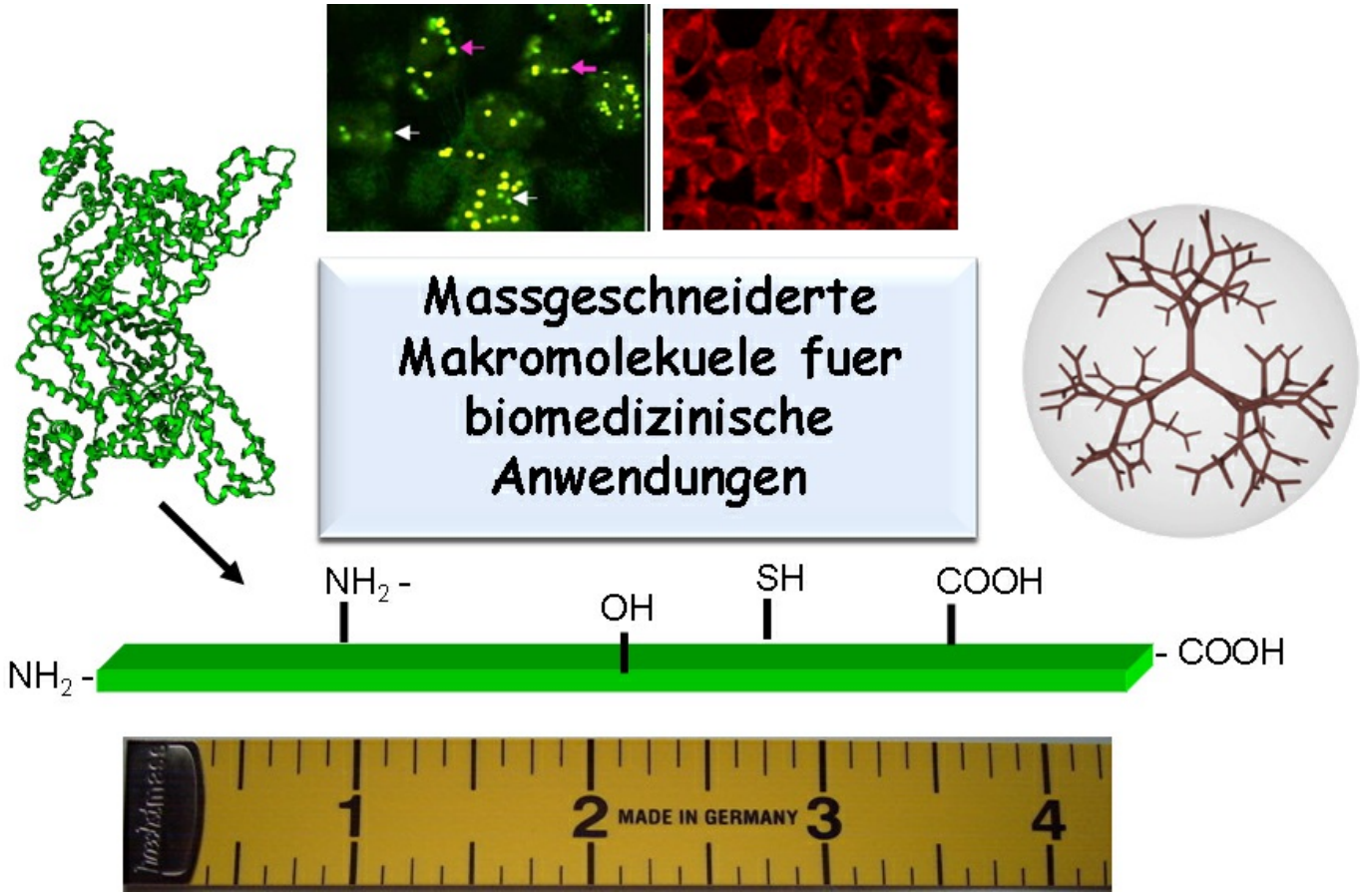


Others are happy about artfully folded proteins, but that is not so for Tanja Weil whose first objective it is to denature them. © Weil

As Merz Pharmaceuticals did not want to lose her, the company supported her research activities and it was not long before a group of three researchers commenced their basic research activities at the Mainz-based Max Planck Institute for Polymer Research with the goal to develop innovative protein materials. Her work in the industry opened the doors into research for Tanja Weil and provided the freedom that she sought in order to realise own ideas in addition to making a living in the pharmaceutical industry.

For private reasons, she accepted a position as an associated professor at the National University of Singapore (NUS) in 2008 and established her own research group. When she learned about a vacant position at the Institute of Organic Chemistry in Ulm that would enable her to deal with material sciences, she was not reluctant to leave Southeast Asia and to return back to Germany, where she "found the conditions that I was looking for". Five Asian doctoral students came along with their 'boss', who is now establishing her research group in Ulm.

Interdisciplinary research that poses the right questions



Biohybrid materials are suited for medical applications, for example for the more effective transport of drugs into cells.
© Weil

Weil does not have plans to cast her pharmaceutical expertise, which is characterised by interdisciplinary cooperation, overboard. She intends to bring together pharmaceutical expertise with academic research on a higher level in order to pose the right questions and work closely together with users, for example medical doctors. Weil has brought substances into the "drug discovery pipeline", and she knows pharmaceutical R&D in and out. In addition, she is well aware of the numerous obstacles that prevent the effect transfer of substances into clinical application.

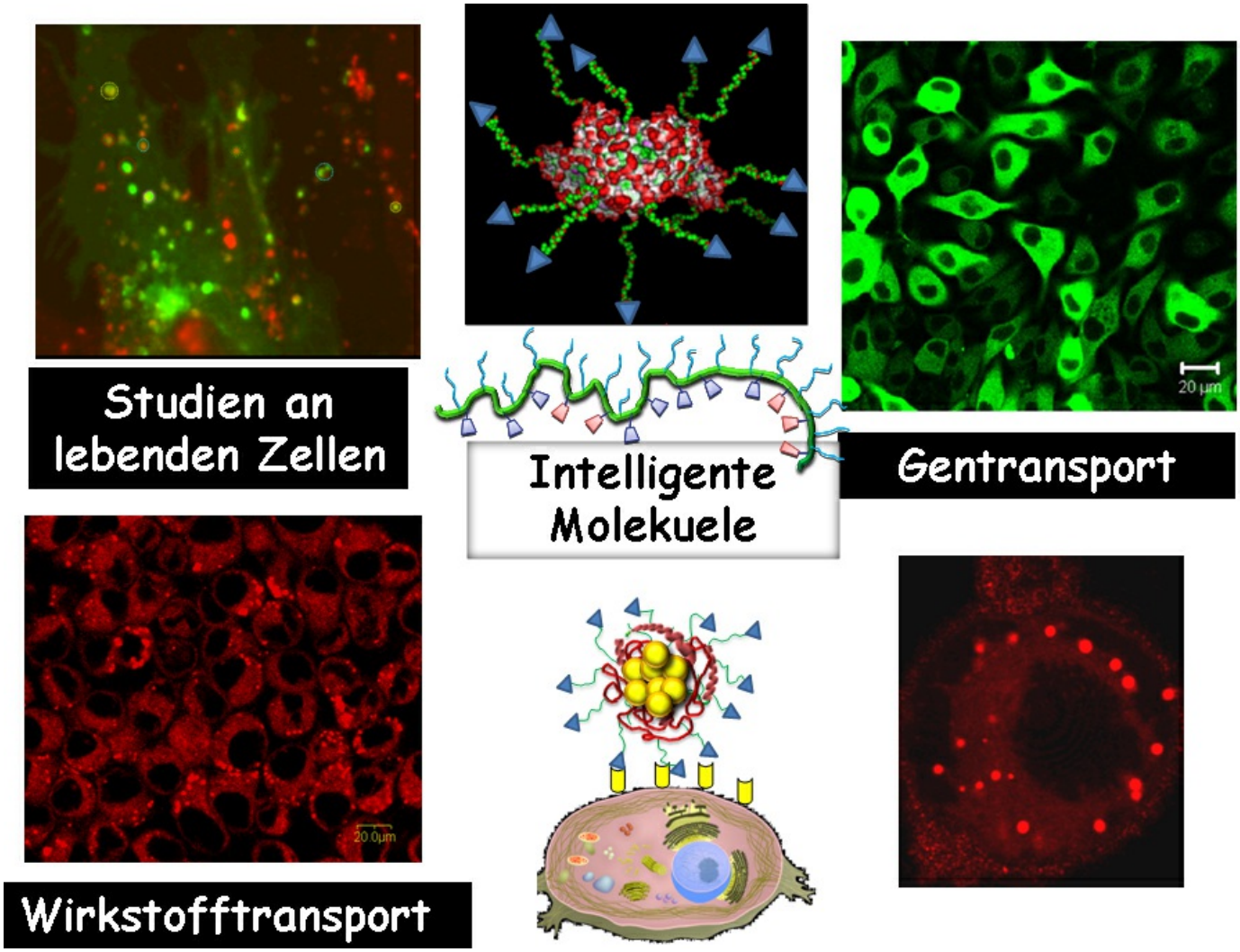
In Singapore, Weil was predominantly focussed on pharmaceutical issues. However, her biohybrid materials are not limited to medical application. In principle, Weil has plans to develop a new synthesis chemistry that enables her to conduct directed chemistry in aqueous solutions. For her, this is a prerequisite for being able to effectively carry out chemical reactions with proteins, and perhaps also with DNA.

Complex tasks require complex molecules

Complex tasks are performed by complex molecules such as proteins, said Weil in trying to cancel out the erroneous opinion that simple molecules are easily able to carry out complex tasks. Proteins undergo numerous chemical modifications on their way into the cells. Researchers who intend to design an ideal carrier molecule for a highly effective cancer drug, are well advised to use complex structures that need to have a broad range of different properties.

Such a broad range of different properties can only be achieved by combining different materials. Materials need to be combined in order to enable the molecules to find their proper destination and release their therapeutic cargo. Such a process requires the use of organic chemistry, polymer chemistry and biochemistry. Weil's group of researchers also need to combine these disciplines in

order to turn an idea of Weil's Chinese doctoral student into reality, namely the use of proteins as the basis for new polymers.



Complex tasks require complex molecules
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Unfolded protein as the basis for multifunctional polymers

Before a protein can be used for the production of polymers, it must be unfolded and stabilised. A macromolecule with only one chain length enables the design of completely new materials. The unfolded protein only has one sequence of definite length. In contrast, 'true' polymers are characterised by a wide distribution of chain lengths. This chemically exactly defined starting substance can be functionalised further into a multifunctional polymer whose different functions can be addressed chemically. Tanja Weil explains that it is possible to vary the chain length if they choose to use a smaller protein as the starting substance.

The process of material design is not always straightforward. "We have to be ready for surprises," said the scientist from Ulm highlighting the example of a cooperation partner whose nanoparticles were unable to enter the cells and who wanted to know whether her "pseudopolymer" was suitable for the coating of surfaces, assuming that it was biologically and cell compatible and had numerous water-soluble functions. Weil's team tested the idea and came up with a cell sensor for pH changes. Weil makes sure to highlight that this was anything but their original idea of designing the polymer.

New, exactly defined structures as attachments

Weil hopes that she will be able to induce the protein-based pseudopolymer of an exact length to form exactly determined superordinated structures. In analogy to the polymers that consist of a broad range of different chain lengths and, therefore, molecular weights, the researchers intend to attach new, exactly defined structures to the protein-based one-chain polymer. In a future project, Weil's team will focus on the potential effects of the new 'appendices' on the polymer's characteristics and structure formation.

This type of work greatly benefits from the interdisciplinary character of Weil's team, which comprises chemists, biochemists and biotechnologists, as well as from the chemists at Ulm University who have great competences in materials science. The chemistry department has established techniques, methods and instruments that are required to characterise the new hybrid materials and develop them further.

Tanja Weil does not only focus on research; she is also greatly committed to teaching. She introduces the students to interdisciplinary thinking, which is something that she has experienced during her professional career and that she practices in her research group. She finds it extremely necessary that students and up-and-coming scientists speak the same language, that the students look beyond the borders of their own discipline, which is chemistry, and contact cooperation partners to learn about the effects of molecules in tissue or stem cells, thereby obtaining new ideas and impulses for their own work.

The former pharmaceutical manager knows very well as to what personnel development means, she makes demands on, and supports, her team. Sentences, such as the following, clearly illustrate this: "We all sit at one table and develop ideas further. Sure, I am still the driver, as this is my job – but why should I not make use of the intelligent people whom we teach and train?"

Weil's new chemistry also focuses on energy production

Despite her long-standing experiences gained in the industry, Tanja Weil makes sure to highlight that "we are primarily focussed on basic research in chemistry and polymer chemistry. Now, we are thinking about potential applications. Thereafter, we will also develop new chemistry." Moreover, new chemistry is not only focused on medicine. Weil's doctoral thesis dealt with colour cascades and she knows that the most effective light collector systems can be found in nature, in chlorophyll, for example, which is part of the reaction centres in leaves where the primary energy conversion reactions of photosynthesis take place. Weil, who is acquainted with the energy research priority of the natural sciences faculties of Ulm University located at 'Oberer Eselsberg', believes that these concepts might be used for the advancement of solar cells.

Weil's first term in Ulm is drawing to a close, but there is still quite a lot of work to be done. Tanja Weil has initiated the first contacts with scientists in Ulm and has found her first cooperation partners. She has plans to support the initiatives of Ulm University to establish a collaborative research centre dealing with nanomedicine and a 'pharmaceutical biotechnology' master's degree programme.

In August 2010, four bachelor's degree students will become part of her team. Tanja Weil hopes to keep the master's degree students by providing them with excellent research and education. Once this integration phase is finished and synthetic chemistry has once again been established, Tanja Weil has plans to start new initiatives. Maybe her dream will come true in that 'her' molecule or 'her'

biomaterial will lead to a development that will eventually be to the benefit of patients.

Article

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