Cooperation with **JAPAN**

The Max Planck Society has 104 cooperation projects with scientists in Japan; 198 Japanese researchers visited a Max Planck Institute in Germany as a guest in 2013. In addition, the Max Planck Society has enjoyed close ties with Japan's leading research organization RIKEN for 30 years through a joint research agreement. RIKEN was founded in 1917, based on the model of the Kaiser Wilhelm Society.

All of this is reason enough to introduce some of the successes of this German-Japanese cooperation in a small, special edition of our research magazine. Cooperation projects with Max Planck can be found all over Japan, for example in Tokyo, Nagoya, Okazaki and Fukuoka. Topics range from astronomy, materials research and neuroscience to chemical ecology. And the collaboration is currently being further expanded in the form of two Max Planck Centers: the Max Planck RIKEN Center for Systems Chemical Biology and the Max Planck – The University of Tokyo Center for Integrative Inflammology.

Image: Shutterstock


Ibaraki / Fukuoka
MPI für Eisenforschung GmbH / National Institute for Materials Science / Kyushu University
Tokyo / Minamimaki
MPI for Astronomy / University of Electro-Communications
Tohoku
MPI for Polymer Research / Tohoku University
Nagoya / Yokohama
MPI for Molecular Biomedicine / Nagoya University / Yokohama City University
Tokyo / Tsukaba
MPI for Chemical Ecology / Graduate School of Agricultural and Life Sciences, University of Tokyo / National Institute of Agrobiological Sciences
Tokyo
MPI for Astronomy / National Astronomical Observatory of Japan
Tokyo
MPI for Polymer Research / Metropolitan University Tokyo
Okazaki
MPI for Cognition and Neurosciences / National Institute for Physiological Sciences
Wako
MPI of Colloids and Interfaces / RIKEN Advanced Science Institute

Sugar Chains and Smoker's Cough

For the last three years, packages containing sugar molecules have regularly made their way from Germany to the Japanese city of Wako, north of Tokyo. The sender is **Peter H. Seeberger's department** at the **Max Planck Institute of Colloids and Interfaces**, and the addressee is **Naoyuki Taniguchi** at the **RIKEN Advanced Science Institute**.

TEXT **CLAUDIA STEINERT**

The scientists have been pooling their expertise at the RIKEN Max Planck Joint Research Center for Systems Chemical Biology since 2011. "The center combines the power of automated sugar synthesis developed at Max Planck with the medical expertise of the physicians at RIKEN to allow fundamental insights into a devastating disease that would be impossible for each institution by itself," says Peter H. Seeberger, Director at the Max Planck Institute in Potsdam. While the scientists in Germany specialize in the synthesis of complex sugars and have gathered a large collection of different chemical compounds, their colleagues in Japan are experts in the field of glycobiology and conduct research into the role of sugar chains in disease, among other things. "Almost everyone at our end is a chemist. We can produce first-rate molecules, but then we need a group that's more focused on biology to test their function," explains Daniel Varón Silva of the Max Planck Institute of Colloids and Interfaces.

The fact is, our body is teeming with proteins that have sugar chains attached to them. In some cases, there might be just a few molecules, while other times there is more sugar than protein. These glycoproteins, to use the technical term, are important components of cell membranes and also function as signal molecules. When signalling pathways are disturbed, it frequently leads to disease. This is why glycoproteins have long been the focus of Naoyuki Taniguchi's research team.

GLYCOPROTEINS INVOLVED IN SMOKER'S LUNG

In one of his projects, the Japanese scientist is studying the onset of emphysema. Also known colloquially as smoker's lung, this condition is a chronic obstructive pulmonary disease (COPD). Cigarette smoke and other airborne pollutants damage the cell membrane of the tiny air sacs, or alveoli, where gas exchange takes place. The tissue disintegrates, the alveoli become large pockets, and soon the air can no longer be exhaled. The used, low-oxygen air is trapped in the lung and the patient is plagued by a wet cough and life-threatening shortness of breath.

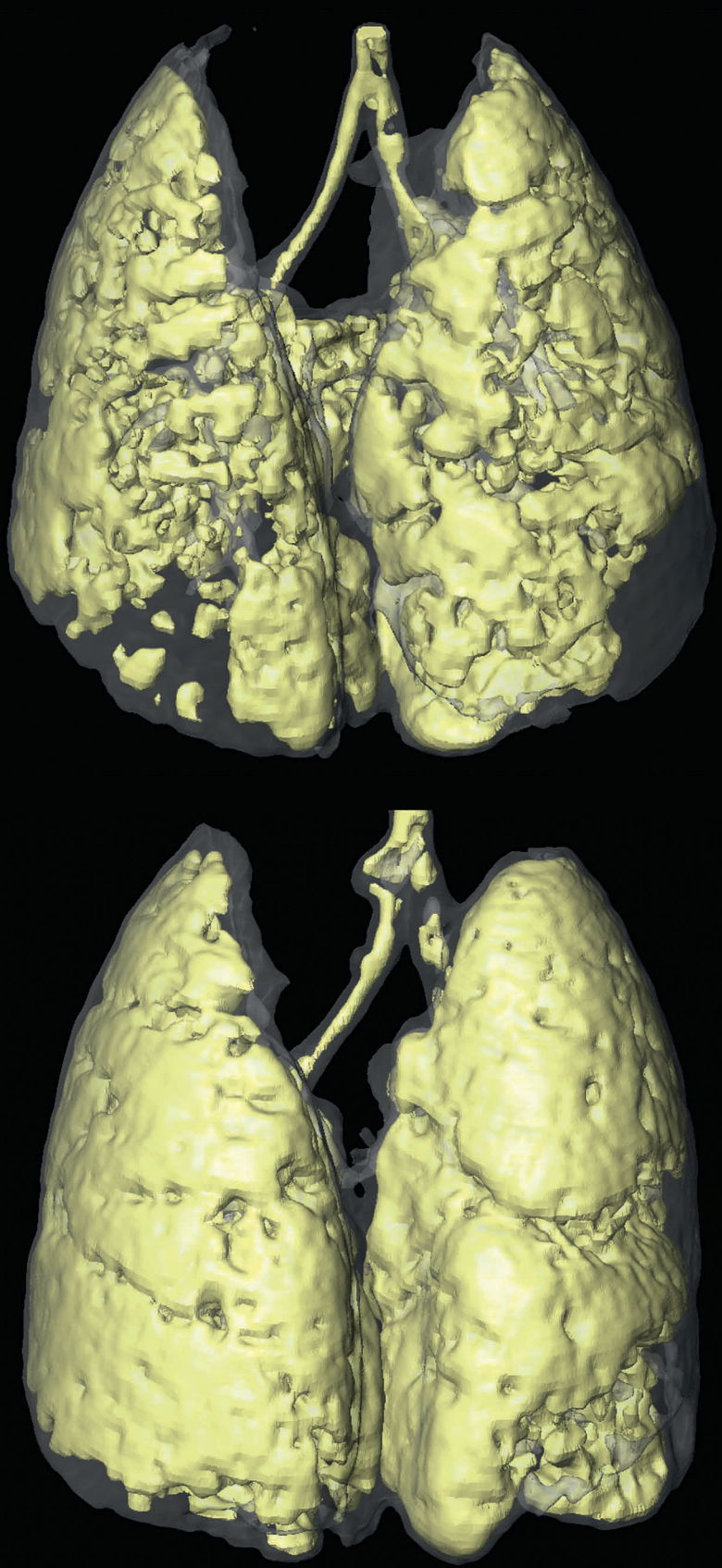
Some three million people around the world die every year from COPD, making it the third leading cause of death, according to the World Health Organization. Although lifelong smokers bear an especially high risk of COPD, only one in five actually suffer this fate, indicating that some individuals are better protected from it by their genetic disposition.

A team headed by Naoyuki Taniguchi recently discovered that a gene called *Fut8* plays an important role in the onset of emphysema. *Fut8* is responsible for attaching fucose sugar molecules to glycoproteins, thereby changing their function. Mice with less *Fut8* developed emphysema after just three months of exposure to cigarette smoke, while mice with normal *Fut8* levels displayed the symptoms only after six months.

Blood tests on former smokers corroborate these results. People with lower *Fut8* activity exhibited a worse lung condition and suffered more intense COPD episodes than those with raised *Fut8* levels. This protein may lend itself as a biomarker to predict the course of the disease in individual patients.

In a new project together with Bernd Lepenies from the Max Planck Institute, Taniguchi hopes to discover which immune receptors detect the sugar molecule during COPD. "We have created a library of possible receptors and are now searching for the right candidate," explains Lepenies. ◀

Image: 2013 Reiko Fujinawa, RIKEN Global Research Cluster



Micro-computed X-ray tomography of lung emphysema (yellow) in mice. To study the disease, scientists developed a mouse model in which the chemical elastase triggers emphysema-like lung disease. Mice treated with elastase and exposed to the bacterial cell wall component lipopolysaccharide show accelerated progression of the disease (bottom) compared with animals exposed only to saline solution (top).

Successful Hunt for Exoplanets

German and Japanese astronomers at the Subaru telescope scrutinize the immediate neighborhood of distant stars

With a mirror diameter of 8.2 meters, the Subaru telescope is one of the largest individual telescopes in the world. The National Astronomical Observatory of Japan (NAOJ) operates this giant eye on the summit of the extinct Mauna Kea volcano in Hawaii. Researchers from the Heidelberg Max Planck Institute are part of a cooperation that allows them to participate in observation programs here – rather successfully, as it turns out.

The German and Japanese scientists are working together in the SEEDS project (**S**trategic **E**xplorations of **E**xoplanets and **D**isks with **S**ubaru). The data required here is provided by the HiCIAO high-contrast camera and the IRCS infrared camera, among others. The Japanese and German teams working on the SEEDS survey are led by Motohide Tamura and Thomas Henning, respectively. Recently, the group again studied a distant planetary system and obtained infrared images of the Jupiter-like object known as GJ 504b.

Image gallery of gas and dust disks around young stars: The near-infrared images were taken by German and Japanese researchers using the Subaru telescope as part of the SEEDS project. These observations help scientists understand how new planets are formed in such disks around young stars.

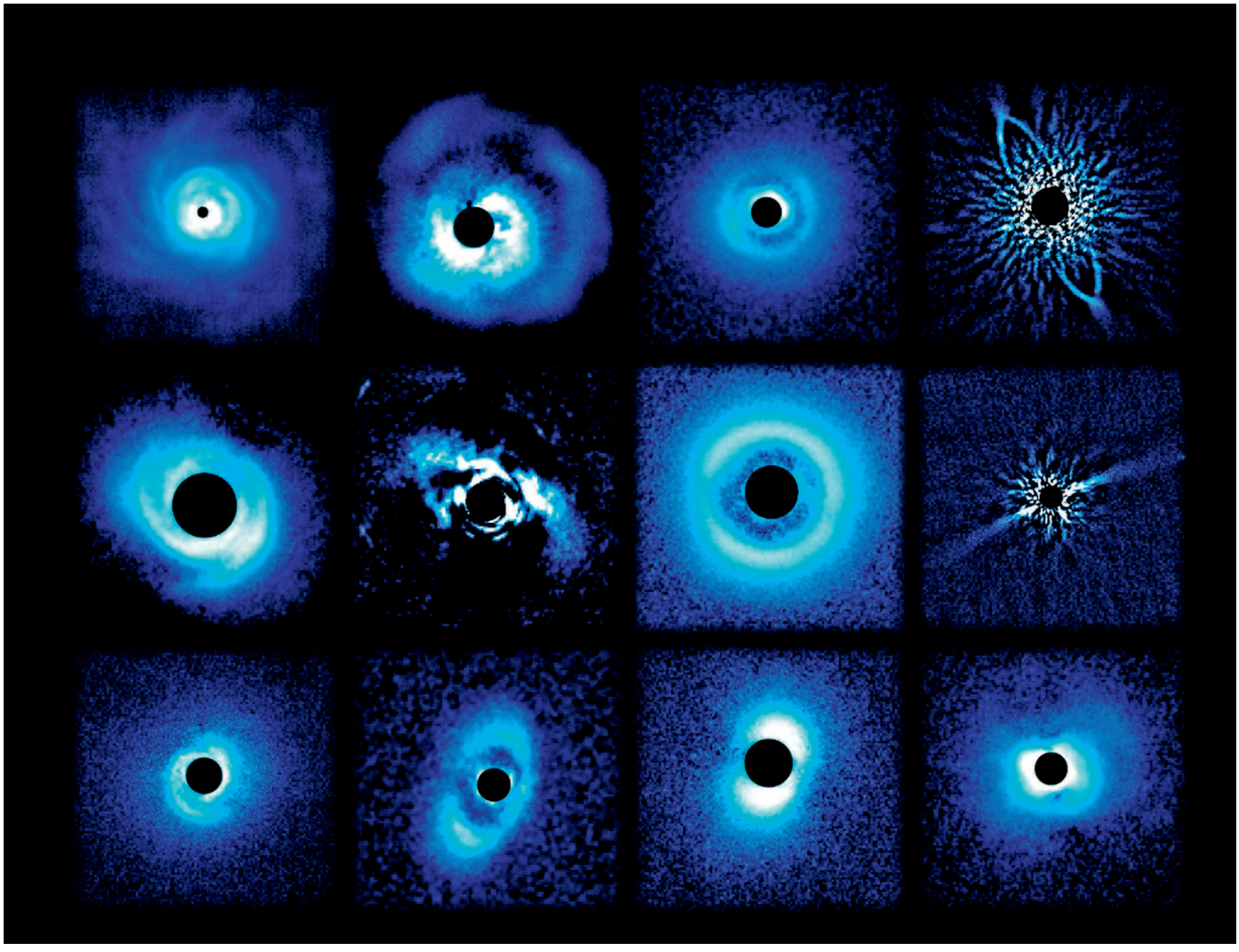


Image: NAOJ

These portraits are the first of a celestial body that orbits a Sun-like star – GJ 504, which is around 60 light-years away in the Virgo constellation. The distance between the planet and its parent star is 44 times Earth's average distance from the Sun, around 6 billion kilometers. Researchers estimate its mass to be around three Jupiter masses. This means that GJ 504b would also be the lightest of all the exoplanets photographed to date, and certainly the coldest.

Almost all of the more than 1,000 exoplanets known at present were detected only indirectly: either by their gravitational effect on their host stars or because they regularly shade out a tiny fraction of the light from this star. Although direct images are rare, they are extremely useful. They provide indications of temperature and some atmospheric properties of the planets observed, among other things.

It is very difficult to image exoplanets directly. The glare of the stars hides their planets – typical intensity ratios are one to a billion or more. This would be like trying to take a photograph of a dust particle orbiting a 100-watt light bulb at a distance of 8 centimeters while standing 80 kilometers away.

The only way to make the planets visible at all in such images is by employing sophisticated technical tricks. These include methods that block the light of the star by mechanical means (coronography) as well as analytical methods that combine several images of the planetary system under investigation in precisely the right way to suppress image interferences.

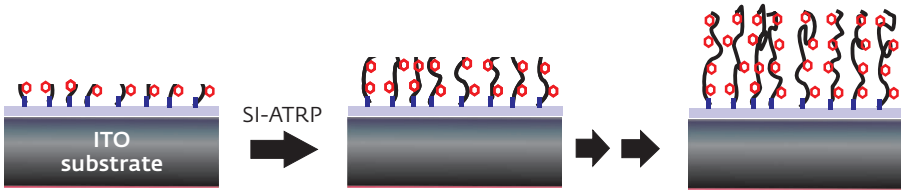
The SEEDS project, which recently passed its halfway mark, has provided more than just impressive images of GJ 504b. The scientists have also photographed disks of gas and dust surrounding young stars from which the planets of these stars are formed.

The Max Planck Institute for Astronomy is one of the founding members of SEEDS. "The researchers of our Star and Planet Formation Department have a wealth of experience in terms of observation strategies, image processing of the high-contrast images necessary for direct imaging, and modeling of the physical properties of exoplanets," says Max Planck Director Thomas Henning. "We were therefore an obvious partner for SEEDS – and we are absolutely delighted that so much progress has been made in recent years!"

Data Carpet in a Memory Chip

Scratchproof polymer coatings pave the way for organic data storage devices of the future

In the future, organic coatings could be used in memory chips in order to make the components printable and low cost. Researchers in Rüdiger Berger's group at the Max Planck Institute for Polymer Research in Mainz have teamed up with partners at the University in Tohoku, among others, to develop surfaces with scratchproof coatings from a redox-active polymer. The electrical resistance of these polymer coatings can be changed specifically in tiny areas with the aid of a very sharp, conducting tip. Data bits can thus be stored in the coating and read again many hours later. These properties make them promising candidates for future organic data storage devices. However, the writing and reading process can abrade the polymers over time. The Mainz-based scientists have therefore undertaken a further project to make the polymer coatings even more robust. They couple the chain molecules to a surface in such a way that they line up next to each other like the fibers of a carpet. The storage density in such a data carpet is around one terabit per square inch, which corresponds to the content of more than four DVDs on one square centimeter.



By chain elongation to a data carpet: Based on the results of the cooperation with Tohoku University, Max Planck researchers grew polymer chains on a substrate via a technique called surface initiated atomic transfer radical polymerization (SI-ATRP). The resulting polymer carpets might be useful for solar cells or organic memory devices.

Image: A. Golriz et al., ACS Applied Materials & Interfaces, 5 2485–2494 (2013)

Birth of a Star in the Radio Telescope

German and Japanese astronomers observe filaments in molecular clouds

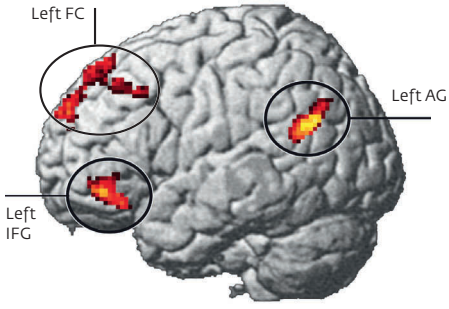
The birth of stars is a complex process: Large molecular clouds initially contract into elongated thin filaments. Inside these filaments, the smaller cores of molecular clouds form, and these clouds eventually give birth to one or more stars. Jochen Tackenberg and Henrik Beuther from the Max Planck Institute for Astronomy in Heidelberg observed how the gas in these filaments moves. They recorded radiation emitted at a wavelength of three millimeters from rotational transitions of the diazenyl ions (N_2H^+). Since these ions occur only in relatively dense regions, and moreover are destroyed during the course of the subsequent star formation, they are ideal for visualizing the early collapse phase and the filaments in particular. But only a sufficiently large radio telescope shows the details. Tackenberg, Beuther and colleagues therefore teamed up with Takeshi Sakai from the University of Electro-Communications in Tokyo. The researchers used the 45-meter Nobeyama radio telescope in the "Japanese Alps" on Honshu to investigate around 16 large molecular filaments in greater detail. The images clearly show how gas flows along elongated filaments toward the cores of molecular clouds.

Listening in on space: The dish of the Nobeyama radio telescope on Honshu is 45 meters in diameter. The instrument provides detailed views of the birthplaces of stars.

Brain Responses to Negation

In Japanese and German, the same brain areas are responsible for similar language processes

Japanese and German could hardly be any more different. They belong to separate language families and differ in phonetics, grammar and sentence structure. Nevertheless, the brain processes many aspects of these elements similarly. Scientists from the National Institute for Physiological Sciences in Okazaki, Japan, in collaboration with the Max Planck Institute for Cognition and Neurosciences in Leipzig, Germany, found out that the same linguistic processes can even activate the same brain areas in both languages. In experiments using functional magnetic resonance imaging, the researchers tested Japanese sentences using the special marker しか ('shika'). These sentences require two constraints. First, they must include a negative marker, ない ('nai'), corresponding to "not" in English, e.g. ペーターしか歌を歌わない ('Anybody other than Peter does not sing songs' or "Only Peter sings songs"). Secondly, the 'shika' marker generates a focus interpretation, similar to "only" in English, e.g. "Only Peter sings songs." By including other Japanese sentences with 'shika', the scientists discovered that the left inferior frontal gyrus is responsible for the syntactic process required by 'shika'. In addition, a focused phrase in Japanese activates a semantic network that comprises the left frontal cortex and the angular gyrus in the left temporo-parietal cortex. These results are comparable to findings in German indicating that the same brain areas are recruited when similar underlying processes take place, despite other important differences between Japanese and German.



Whereas the left inferior frontal gyrus (IFG) is responsible for complex negations in Japanese and German, a focused phrase relies on neuronal activity in the frontal cortex (FC) and the angular gyrus (AG).

Images: NRO (above), National Institute for Physiological Sciences in Okazaki, Japan - Hirotani Sadato (below)

Captive Breeding Has Impaired Olfactory Functions in Silkmoths

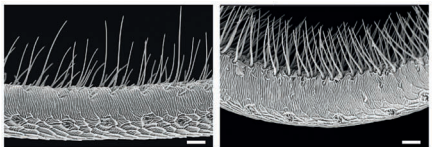
Domesticated silkmoths have a much more limited perception of environmental odors compared with their wild relatives

Bombyx mori (left) and *Bombyx mandarina* (right) females. The domesticated moth has lost its camouflage coloration as well as its ability to fly.

The silkmoth *Bombyx mori*, originally native to China, was domesticated about 5,000 years ago. Its larvae, silkworms, enclose themselves in a cocoon when they enter the pupa phase. They spin their cocoon from one single silk thread, which is several hundred meters long. For silk production, the cocoon – together with the pupa inside – is boiled and the silk filament is then unravelled. Special breeding moths are kept for silk farming. After mating, female moths lay several hundred eggs from which the new silkworms hatch.

Scientists from the the Max Planck Institute for Chemical Ecology and their collaborators from Japan have found that domesticated silkmoths are now considerably impaired in their olfactory functions due to captive breeding. The moth's perception of environmental odors, which may lead it to its exclusive host plant, the mulberry tree, has been significantly reduced. This was demonstrated when their responses to odor stimulation were compared with those of the closely related wild species *Bombyx mandarina*. The scientists recorded electroantennograms of individuals of both species that were stimulated with different scents from leaves or flowers. Morphological analysis revealed that the number of sensilla on the antennae of the domesticated females is considerably reduced compared with the abundant sensilla of their wild relatives.

In addition, the researchers measured different activity patterns in the brain of the domesticated and the wild silkmoths by using calcium imaging techniques. These patterns were highly variable among individuals of domesticated silkmoths, but were largely constant in their wild ancestor group as well as in four other insect species.

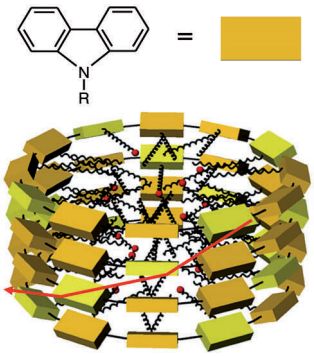


In the domesticated species, the number of sensilla is considerably reduced (left) in comparison with its closely related wild ancestor (right).

Compared with wild moths, domesticated silkmoths seem to have less ability to smell environmental odors with their antennae and to locate host plants due to several millennia in captivity. As oviposition substrate is provided by humans, this ability has become redundant. In the wild, however, selecting an adequate oviposition site is crucial for the survival of the offspring, and thus helps preserve the species.

Aromatic, with a Filling

Cyclic molecules loaded with other substances self-organize to form components for solar cells and nanowires



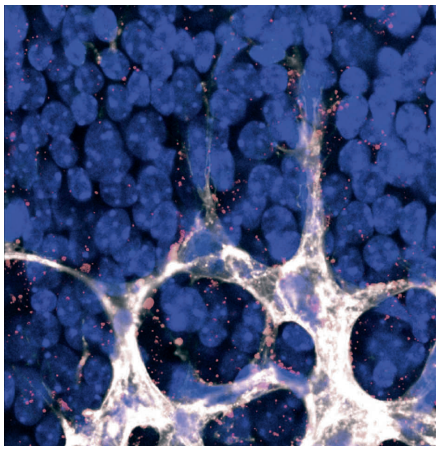
Electronics in a stack: Macrocycles of substituted carbazols (yellow and greenish cuboids) organize themselves in layers. Structures like these might be interesting for devices of organic electronic.

Some substances have a strong desire to arrange themselves in an orderly way. Large aromatic molecules that resemble disks and rings cut from chicken wire stack up of their own accord in columns on a suitable substrate. A collaboration including scientists from the Max Planck Institute for Polymer Research and Tokyo Metropolitan University, among others, is using this principle of self-organization to produce nanostructures for electronic components. They use aromatic hydrocarbon rings, for example, into whose center they pack graphene, dye molecules or metal ions. The stacks that grow in this way could serve as components for photovoltaic cells or the starting material for custom-made nanowires, depending on their filling. In order to identify the best hybrid materials to use here, the cooperation partners test the physical properties of nanostructures made of different components and investigate the charge transport through the stack or their photovoltaic qualities, for example.

Images: MPI for Chemical Ecology / Markus Knaden (above, right), MPI for Chemical Ecology / Sonja Bisch-Knaden (above, left), MPI für Polymerforschung - Muellen (below)

From Tip to Base

Differences in growth factor receptor turnover underlie the maturation of sprouting blood vessels



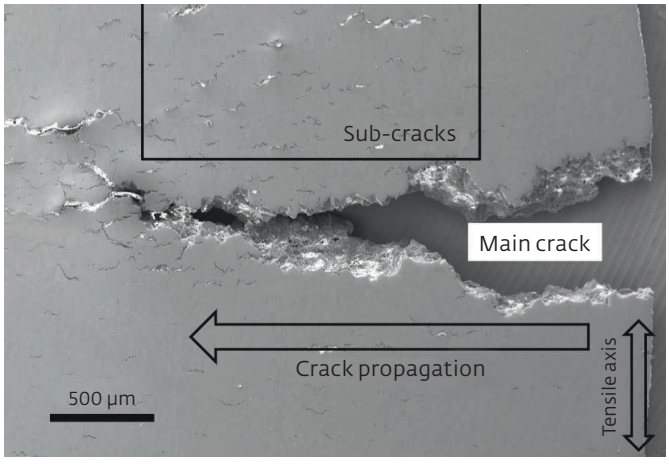
Binding and uptake of labeled VEGF (red) by sprouting endothelial cells (white) in the postnatal retina of the mouse. Cell nuclei are labeled in blue.

During development and regeneration, new blood vessels are rapidly formed to provide nutrients and oxygen to the new tissue. To this end, endothelial cells at the edge of the growing vessel network must react sensitively and quickly to cues in the environment. Vascular endothelial growth factor (VEGF), for example, acts as a signpost that guides growing vessels in the right direction. Endothelial cells at the tips of vessel sprouts rapidly internalize VEGF receptors, thus changing the receptors' signaling properties. In contrast, cells in previously established, more mature vessels bear fewer VEGF receptors and form a more stable network. According to scientists from the University of Nagoya, the City University of Yokohama, Japan, and the Max Planck Institute for Molecular Biomedicine in Münster, Germany, the regulation of surface receptor endocytosis might underlie the transition of VEGF-sensitive sprouts into mature vessels. The researchers discovered that, in the developing mouse retina, endothelial cells at the tips of the vessels rapidly take up VEGF and internalize VEGF receptors. In established vessels, however, the enzyme atypical protein kinase C inhibits this process. The scientists found that the active form of this enzyme was abundant in maturing endothelial tubes, but absent from sprouts. Atypical protein kinase C thus promotes the transition of endothelial sprouts into mature vessels.

Delving into Cracks

A detailed understanding of how cracks form in hydrogenated steels helps in the development of more robust materials

Using hydrogen on a large scale as a fuel is a challenge – and not just for the energy sector, but for materials scientists, too. This is because the tiny hydrogen atoms can easily penetrate into the steels of tanks or pipelines, for example, and cause the material to become brittle. Researchers at the Max-Planck-Institut für Eisenforschung GmbH, the National Institute for Materials Science in Ibaraki, and Kyushu University in Fukuoka are investigating where exactly cracks develop in hydrogenated steels and the role the gas plays in this process. The research has shown that the first hairline cracks open up not only at the boundaries between the microscopic crystal grains that make up the alloys, as occurs in hydrogen-free steels. They also form within the grains, at very well-matched crystal boundaries, known as twin positions of the atoms, which previously were not thought to be susceptible to crack formation. As soon as the researchers understand this hydrogen embrittlement in detail, they want to develop materials that exhibit better resistance.



Cracked by hydrogen: The tiny molecules of the gas creep deeply into steel and weaken it, so that it breaks more easily under tensile forces than without the gas load.

Images: Max-Planck-Institute for Molecular Biomedicine (above), Acta Materialia 61 (2013) 4607–4618 (below)