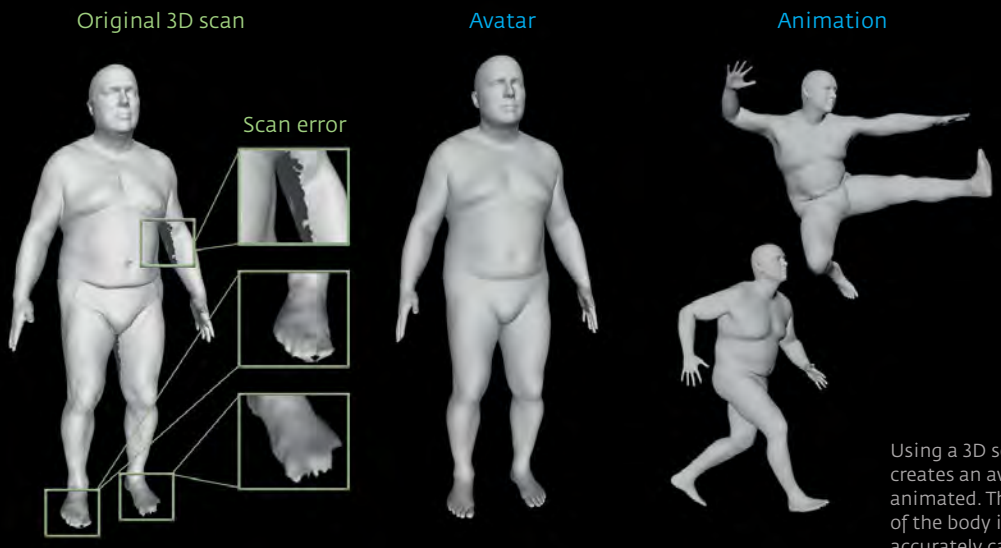
Avatars for everyone

Meshcapade creates 3D models of human bodies – and not only for animation in movies and computer games



Using a 3D scan, Meshcapade's software creates an avatar that can be realistically animated. The program can correct the parts of the body in the 3D model that are not accurately captured by the 3D scan – in this case a region of the upper arm and a few toes.

The startup from Tuebingen produces software that makes it easier than ever before to create animated three-dimensional models of human bodies. Meshcapade was founded by Michael Black, the Director of the Max Planck Institute for Intelligent Systems, along with Naureen Mahmood and Talha Zaman, two of his former coworkers. "Our software generates realistic avatars and movements that customers can utilize in a wide range of applications," says Naureen Mahmood, the company's Managing Director.

Such models can be used to create convincingly animated characters in films and computer games and realistic protagonists in virtual and augmented reality. Online clothing retailers scan these avatars to allow their customers to try on clothes virtually, on a model of their body that can vary in terms of both shape and activity. Robots can also use the avatars to train how to interact with people. And that's not all that 3D models have to offer.

Meshcapade is extremely versatile, chiefly because it's able to create avatars from data of widely varying quality. Motion analysis is probably the most comprehensive data collection method. Cameras record the paths of 30 to 40 reflective markers at key points on the body worn by a person in motion. The Meshcapade software converts the movements of the markers into a 3D model of the person. Meshcapade, however, can also analyze 3D scans of individuals. Since such scans are often poor in quality, the relevant software can only create static models from them. "We can even generate fairly realistic models from simple body measurements such as height, weight, and hip and shoulder circumferences," says Naureen Mahmood.

Soon Meshcapade will even be able to create 3D avatars using photos and videos. "We are continuing research into making the techniques more robust and versatile, but we can already create 3D models from photos, paving the way for many exciting applications," says Naureen Mahmood. As a result, frequenting cyberspace using virtual representations of our own bodies may become increasingly common. At the very least, we'll be meeting figures online more often with realistic body proportions that move realistically.

Graphic: Meshcapade

Reliable DNA copier

A biochemical trick to prevent errors during DNA amplification

Some scientists achieve breakthroughs by combining familiar ideas from different fields in surprising ways. Igor Ivanov is a case in point: his combination of two standard molecular-biological methods started a genuine revolution.

The story, which the scientist describes as a fairytale come true, begins in the early 1980s. While working on his diploma thesis, Ivanov, originally a physicist, spent several months in a molecular biology laboratory in Moscow, where he became acquainted with a method of cross-linking separate DNA strands using formaldehyde. Years later, he was conducting postdoctoral research at the Max Planck Institute for Molecular Genetics in Hans Lehrach's Department. Then as now, everyday laboratory work was dominated by the polymerase chain reaction (PCR), a standard technique for amplifying DNA. DNA polymerase plays a key role in PCR. It is a thermostable enzyme that copies the desired DNA section at 95 degrees Celsius or when additional reagents are added. However, the polymerase is active at much lower temperatures causing non-specific amplification errors. Confronted with this problem in the laboratory, Ivanov came up with a revolutionary solution. He recalled the cross-linking technique from his time in Moscow and added formaldehyde to the polymerase reaction mixture. Aldehyde, a molecule with the chemical formula CH_2O, would bind to the DNA, reasoned Ivanow, and thus block access to the polymerase. Once the higher temperature had been reached at which correct DNA copies are produced, these links would break and the chain reaction would be able to start.

After only a few trial runs, he realized that his method had immense potential and could be successfully marketed. The patent experts at Max Planck Innovation provided him with support, and eventually the decision was made to collaborate with Qiagen, a biotech company with which Igor Ivanov had previously worked. HotStar polymerase became a major money-earner, making a lasting impact on molecular biology. It was a technical – and a financial – success story. By the time the patent expired in 2018, the Max Planck Society had generated revenues in the millions.

Gene ferries for plant breeding

Plasmids derived from bacteria can be utilized to transfer DNA into plants

The "Ti plasmid" is a small, ring-shaped DNA molecule that is transferred into plants by the bacterium *Agrobacterium tumefaciens*. The molecule can trigger genetic changes, and thus tumors, in plants. In the 1970s, researchers at the Max Planck Institute for Plant Breeding Research in Cologne and at the University of Ghent in Belgium developed a novel method that used the plasmid to introduce new genes into plants. This technique substitutes tumor-inducing genes with selected genes in the plasmid. In 1989, Max Planck Innovation granted the marketing license for the Ti plasmid patents to the biotech company Plant Genetic Systems. After several takeovers, Bayer CropScience now holds the patents and still receives royalties for them. Ti plasmids have, for example, allowed crops to be developed that are more resistant to drought and pests.

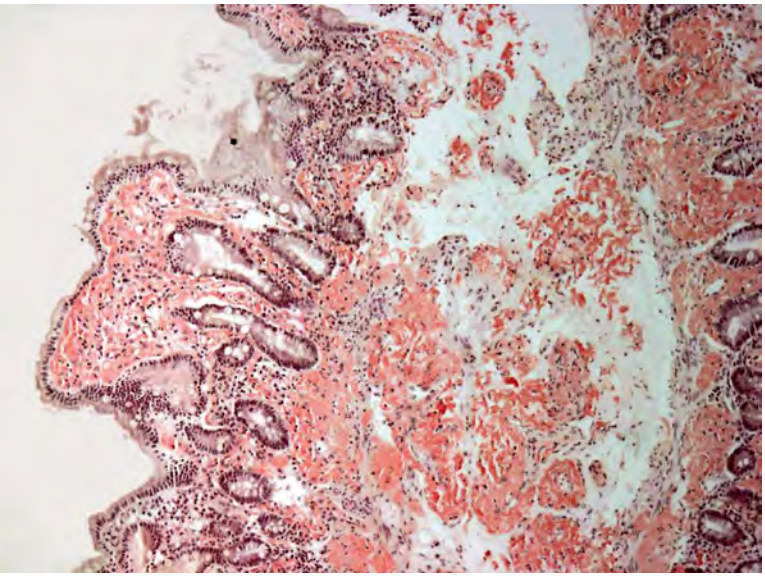
New wheat varieties have been developed to be more resistant to pests, drought and soil salinity. The plants are also expected to produce even higher yields.

Photo: Michael Callaghan / unsplash

New drug class

The drugs patisiran and givosiran are based on a process known as RNA interference and are used to treat rare genetic diseases

Patisiran and givosiran are two completely new drugs to treat rare hereditary diseases and were launched in 2018 and 2019 by the U.S. pharmaceutical company Alnylam Pharmaceuticals. Their discovery was based, among others, on two research projects on RNA interference (RNAi), whose results were patented by the Max Planck Society in 2000. Two years later, Max Planck Innovation granted Alnylam Pharmaceuticals a license to use the RNAi method in clinical medicine.



In amyloidosis, pathologically transformed proteins are deposited outside cells, as seen here in the connective tissue of the duodenum. The deposits are visualized as light red material.

Drugs based on RNAi act at an earlier point in the disease process than other drugs; they prevent the synthesis of disease-causing proteins by silencing the RNA molecules that code for them. RNA molecules are copies of sections of DNA and, among other things, serve as blueprints for protein synthesis. In the late 1990s, two U.S. scientists discovered that the nematode C. elegans can silence RNA molecules and thus genes. Thomas Tuschl and his colleagues from the Max Planck Institute for Biophysical Chemistry in Goettingen analyzed the structure of the molecules involved and discovered that the process of RNA interference also occurs in humans and other mammals. In this way, the researchers laid the foundation for the development of RNAi drugs.

Patisiran, which is being sold under the trade name Onpattro, is the first treatment for patients with transthyretin-related hereditary amyloidosis. It has so far been approved in the U.S. and many European countries, including Germany. The disease is hereditary and leads to progressive disability and, frequently, to death within five years. Patisiran is used to treat nerve damage caused by the disease. Before its authorization, no other drugs were available to treat patients.

By contrast, Givosiran is used to treat patients with acute hepatic porphyria. This rare hereditary disease causes the build-up of toxic porphyrin molecules during the synthesis of the blood pigment hemoglobin. This can result in severe pain, paralysis, respiratory arrest, and seizures.

Givosiran inhibits the formation of these toxic substances. A phase III study found that monthly subcutaneous injections could reduce the frequency of disease attacks by 70 percent. The drug has already been authorized in the U.S. and is currently under review for authorization in Europe.

Approximately one thousand patients have so far been treated with the RNAi drugs. “We anticipate that in the next few years, even more RNAi drugs will be granted authorization,” says the Managing Director of Max Planck Innovation, Jörn Erselius. “The technology represents a textbook example of how basic research can yield completely new treatments. However, patience is sometimes needed; it usually takes ten to fifteen years for a discovery to reach patients.”

In addition to clinical medicine, RNAi is an indispensable tool in basic research. Beyond licenses for use in medicine, Max Planck Innovation has also granted licenses to companies manufacturing research reagents. RNAi enables scientists to investigate the function of genes.

To ensure that the technology would also be further developed outside the U.S., the German start-up company Ribopharma was also granted a license. The following year, however, Alnylam acquired its competitor, so that the company now holds the exclusive commercialization rights. The German RNAi research site was later taken over by Roche and abandoned a few years later when the company withdrew from RNAi technology.

RNAi is therefore a prime example of foreign companies bringing a technology developed in Germany to market maturity and going on to earn substantial profits. However, even though it proved impossible to keep RNAi drug development in Germany, the Max Planck Society has nevertheless made substantial financial gains from the licensing income and the stock flotation of Alnylam in 2004.

Photo: Michael Feldman, MD, PhD, University of Pennsylvania School of Medicine

Corrosion protection to order

The company Enviral manufactures a coating containing tiny capsules that prevent corrosion – as employed, for instance, in the Bauhaus Museum in Dessau

The Bauhaus set standards not only in art and architecture, but also in novel building materials. Its successor institutions, such as the Bauhaus Museum in Dessau, inaugurated in 2019, are no exception. Brandenburg-based company Enviral utilized particularly sophisticated corrosion protection for the steel structure behind the glass facade of the museum. The coating, known as SmartCorr, is composed of nanocapsules containing an anti-corrosion agent. If the coating is scratched, corrosion occurs and the pH value changes, causing the tiny capsules to open. They then release their corrosion-inhibiting contents. The SmartCorr coating is based on a technique developed by a research team led by Helmuth Möhwald at the Max Planck Institute of Colloids and Interfaces in Potsdam. In 2018, Max Planck Innovation licensed the technology to Enviral. Together with three manufacturers of coatings, Enviral has already developed coatings incorporating the nanocapsules as additional corrosion protection. In addition to the Bauhaus Museum in Dessau, the coating, technically a "powder coating", has also been used on other buildings, such as the Thomas Mann House in Los Angeles. The house is on the coast of the Pacific Ocean and is exposed to particularly corrosive conditions. Together with other coating manufacturers, the company is also investigating the capsules as an additive for coatings. The products will benefit both customers and the environment. "SmartCorr coatings are not only more cost-effective but also more sustainable," says Rainer Rogovits, Managing Director of Enviral. "By dispensing with powder coating, we can save materials and energy."

Scratches of coated surfaces often speed up corrosion – but not if the steel is coated with SmartCorr.

Cure for leishmaniasis

One of the world's most devastating infectious diseases was defeated by an anti-cancer drug

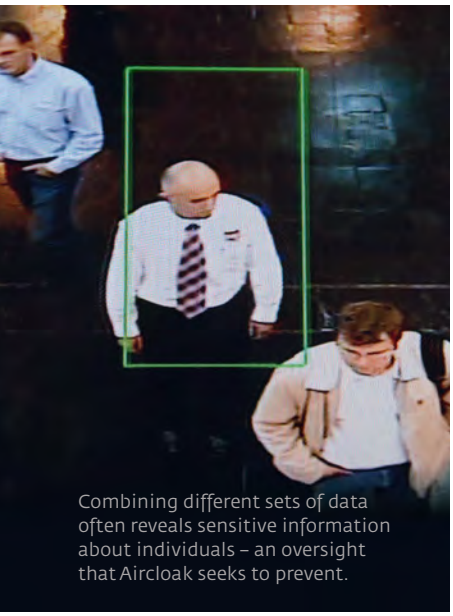
By chance, while searching for a cure for cancer, scientists discovered a cure for leishmaniasis. That's the story of miltefosine, developed in the 1980s by Hansjörg Eibl at the Max Planck Institute for Biophysical Chemistry and Clemens Unger at the University of Freiburg. Marketing authorization for the drug, under the trade name Miltex, was first granted in 1992 to the pharmaceutical company Asta Medica to treat skin metastases in breast cancer patients. However, biochemists also investigated miltefosine's effect on parasitic protozoa such as leishmanias or trypanosomes, since the immune system recognizes these in a similar way to tumor cells. They soon realized that they had struck gold. The drug makes short work of leishmanias, the pathogens that cause visceral leishmaniasis. Every year millions of people fall ill with the disease. Also known as black fever or Dumdum fever, the infection is always fatal if left untreated. However, help is now available: miltefosine, marketed by Zentaris and authorized under the trade name Impavido in India in 2002 and in Germany in 2004, has a success rate of 98 percent when administered as a four-week course of treatment.

At the Max Planck Institute for Biophysical Chemistry, Hansjörg Eibl (right) and Clemens Unger give a lecture on the synthesis of miltefosine, which is effective in treating both breast cancer metastases and visceral leishmaniasis.

Photos: iStock (above), MPI for Biophysical Chemistry (right)

Privacy protection in data treasure troves

Software by the company Aircloak enables customer information to be flexibly anonymized but still evaluated statistically



Combining different sets of data often reveals sensitive information about individuals – an oversight that Aircloak seeks to prevent.

Data is a source of new ideas. Companies can develop products for their customers using information they have on record for them. But data can also be easily misused. Banks, insurance companies and companies in the healthcare sector are obliged to handle their clients' sensitive data with particular care – and not just since the advent of the European General Data Protection Regulation, which strengthened the relevant legislation. However, anonymized customer information is frequently all such companies need to target their services to customers. Since 2016, the Berlin start-up Aircloak, which currently employs a staff of ten, has been marketing software to facilitate this. It allows companies such as financial service providers to reliably extract anonymized information from their data records. Companies employing Aircloak software can formulate a question, which will then be answered by means of a statistical analysis. The steps the software takes to anonymize answers vary depending on the nature of the question asked. Combinations of questions that are more likely to identify individuals, for instance, result in an increased blurring of answers by the the software. For example, an employee could potentially ask for the total income of a group of people followed by information on the total income of this group excluding data from a person "X". Aircloak adapts the answers it provides to these two questions to ensure that while its answers retain some statistical value, they can't be used to calculate the income of X based on the difference between the two answers.

The idea of having data flexibly anonymized by an independent entity, namely a piece of software, was the brainchild of Paul Francis, Director at the Max Planck Institute for Software Systems in Kaiserslautern. "Our software was developed based on this idea," says Felix Bauer, a former employee of Paul Francis and now Managing Director of Aircloak. "We solve the problem that deleting a person's data such as name, date of birth and complete residential address from data records is often not enough to ensure data protection." As things stand, it's possible to reveal data about individuals, both by performing multiple queries on a data set and by linking data from different sources. Aircloak's software prevents this. It helps companies to unearth the treasures in their databases while still safeguarding privacy.

Photos Caro / Oberhaeuser (left); MPI for Extraterrestrial Physics (below)

Cold plasma to combat germs

Ionized gas to sterilize wounds and surgical instruments

What are the various states of matter? Most people would probably give the following standard answers: "solid, liquid, and gas." Gregor Morfill is always keen to add a fourth: plasma. As an astrophysicist, Morfill initially studied plasma – a state in which atoms are present as ions and electrons – because that's what stars are composed of. The interest of the emeritus Director of the Max Planck Institute for Extraterrestrial Physics has now extended to "cold plasma." Unlike the plasma in stars, cold plasma is at a moderate temperature and – as Morfill recognized – can be used as a disinfectant. He developed this concept into a concrete medical application that streams a breath of cold plasma over a wound or target to be disinfected, killing all bacteria and viruses in just minutes. Based on this idea, Gregor Morfill founded the company terraplasma in Garching in 2011.

In addition to wound disinfection and sterilization of surgical instruments, Gregor Morfill's team of researchers has identified several other fields of application. The antibacterial effect of cold plasma can also be used to treat water, for instance to sterilize drinking water. Furthermore, it eliminates molecules that cause odors as well as allergens. Cold plasma can also be used to purify air or reduce exhaust emissions, fields which are currently being investigated by terraplasma and its spin-offs.

Among other things, wounds can be efficiently sterilized using the pale-blue, glowing cold plasma.

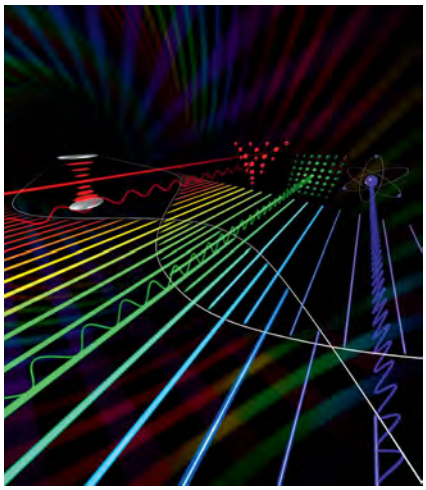
Light combs as yardsticks

A Nobel Prize-winning technology that can improve satellite navigation and measurements of time and distance

Atomic clocks are trailblazers – and not just as timekeepers (they can be accurate to within one second over 30 million years), but also in the more literal sense of the word. That's because atomic clocks are an essential element in satellite navigation systems such as GPS or Galileo. Their accuracy determines how well such systems can pinpoint our position. However, clocks known as optical clocks can be even more accurate than atomic clocks. Optical clocks employ the frequency of a light wave that an atom can absorb or emit when it passes from one energy state to another as a timekeeper. A device known as an "optical frequency comb" enables such transitions to be recorded with extraordinary accuracy. Each "tooth" of the comb is a different color of the rainbow, and the even spacing of these teeth can be specified with extreme precision. Frequency measurements using the optical frequency comb make optical clocks not only more accurate, they also allow different clocks to be compared.

The techniques underlying optical frequency combs were developed by Theodor W. Hänsch, Director at the Max Planck Institute for Quantum Optics in Garching and Professor at the Ludwig Maximilian University in Munich. In 2005 he was awarded the Nobel Prize in Physics for his contributions. Back in 2001, together with Ronald Holzwarth and Michael Mei, he founded Menlo Systems in Martinsried near Munich, which today employs more than 100 people and is the world market leader in optical frequency combs.

The technology can be deployed wherever light frequencies need to be measured with extreme accuracy. In addition to the field of atomic clocks, optical frequency combs can, among other things, also improve the accuracy of pure physics experiments involving spectroscopy and the sensitivity with which trace gases can be analyzed in the atmosphere. Precise frequency measurements can also improve the accuracy of the information garnered from the starlight captured by telescopes, and thus the properties of the stars. Crucially, the light emitted by a star depends, among other things, on the temperature and composition of its surface. Since light wave frequencies can readily be used to determine distances – as evidenced by standard tools from hardware stores to measure distances – frequency combs can also be used in all situations where extremely precise distance measurements are vital, for instance to coordinate swarms of satellites.



Optical frequency combs with their accurately fanned out lines of differently colored light have many applications, for example in spectroscopy.

In addition to optical frequency comb technology, Menlo Systems also offers numerous other advanced products for optical applications, such as femtosecond fiber lasers, which efficiently generate exceptionally short flashes of light. These can be used to shed light on neurological processes or to process materials. The company based in Martinsried also manufactures systems that generate optical frequency combs in the terahertz range. One area of application is in quality control, for example in the plastics and food industries.

Graphic: Menlo Systems

Genetic fingerprinting

Particular fragments of DNA can be used to reliably prove paternity

"Luke, I am your father!" – not all fathers are as open as Star Wars' Darth Vader in admitting the paternity of their children. In cases where doubt has been raised, the matter needs to be settled in court by means of a paternity test, comparing the mother's, father's and child's genetic material.

Diethard Tautz might justifiably be regarded as the father of this technique. A biologist, and now the Director of the Max Planck Institute for Evolutionary Biology in Ploen, Tautz identified specific DNA fragments in the genome of the fruit fly *Drosophila* as part of his doctoral thesis. These fragments known as "short tandem repeats" are short regions of repeated, extremely short DNA sequences. Tautz discovered that each individual possesses a characteristic set of these tandem-like repeats, inheriting these genetic traits half from the father and half from the mother. As a result, they can be used in kinship analysis. Together with Herbert Jäckle, Director at the Max Planck Institute for Biophysical Chemistry, Tautz developed the short-tandem repeat method, a genetic fingerprinting technique that enables paternity to be proven with absolute certainty. This method has also established itself as the standard in forensic science to reveal identities.

The Max Planck Society granted a license for this to the U.S. company Research Genetics in 1993 and a sub-license to Promega, also based in the U.S., in 1996.