

NOBEL PRIZE IN CHEMISTRY



BENJAMIN LIST

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Left- or right-handed? This makes a big difference in chemistry as well. Many molecules, especially those involved in biological processes, exist in two variants. The components of these variants are arranged as mirror images of one another – just like the fingers of our hands.

In chemical reactions, the two variants usually occur in equal proportions. But in biology, they usually have very different effects. This is particularly relevant when it comes to medicinal substances. Benjamin List, Director at the Max-Planck-Institut für Kohlenforschung in Muelheim an der Ruhr, and David W. C. MacMillan of Princeton University independently discovered in the year 2000 that even relatively small, often inexpensive and non-toxic organic molecules can shift a chemical reaction in favor of a single variant. For this, they will receive the Nobel Prize in Chemistry 2021. Before the two researchers made their discovery, this selective effect was known to occur only in enzymes or in relation to elaborate catalysts that often contain expensive or toxic metals.

When Benjamin List first tested the catalytic effect of an organic mole-

cule, namely the amino acid proline, he was rather skeptical: “I was completely unsure. You never think: Wow! I designed that! Now I’ll become world famous! Instead, you think: hmm... maybe this was a really stupid idea. I’m sure others have already tried this and know why it doesn’t work...”. But in fact, no one had tried it yet. And it did work. Today, organic molecules

are often used as catalysts, not only in research but also in industry.

“Benjamin List has begun a new chapter in catalysis with great application potential,” Max Planck President Martin Stratmann explains. “He is the first to succeed in developing organic catalysts with high stereoselectivity – a very rare breakthrough.”



PHOTO: FRANK VINKEN. MEDAILLE: PICTURE ALLIANCE / SZ PHOTO | ALESSANDRA SCHELLNIGER

**“You think: maybe this was
a really stupid idea.”**

NOBEL PRIZE IN PHYSICS

KLAUS
HASSELMANN

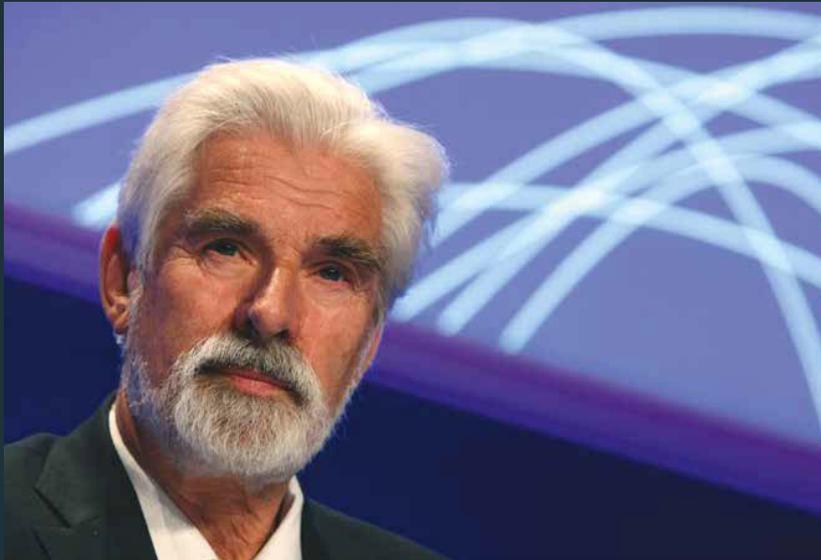


PHOTO: PICTURE ALLIANCE/DPA | J.J. GUILLEN

“We’ve been warning people about climate change for almost 50 years.”

A certain amount of provocation is often necessary, especially in science. With his work, Klaus Hasselmann challenged climate research – and thus laid the foundation for the realization that global warming can be clearly attributed to increasing CO₂ levels in the atmosphere. For this, the former Director at the Max Planck Institute for Meteorology will receive the Nobel Prize

in Physics 2021 together with Syukuro Manabe from the U.S. and Giorgio Parisi from Italy.

Hasselmann introduced the element of chance into climate research, explaining long-term climatic developments as the result of the meteorological background noise, which manifests itself in short-term weather fluctuations. Until

then, nobody had ever considered the climate in this way. He also developed the mathematical tool for detecting the imprint of human CO₂ emissions amongst the meteorological background noise.

“As the founding Director of our Max Planck Institute for Meteorology, Hasselmann, together with his colleagues in Hamburg, played a key role in advancing Earth system research in Germany in the 1970s and 1980s and in making it internationally relevant,” says Max Planck President Martin Stratmann.

In order to convey the findings of climate research to the general public and to develop effective but also practicable measures to combat climate change, Hasselmann founded what is now the Global Climate Forum together with Carlo C. Jaeger of the Potsdam Institute for Climate Impact Research. “There are many things we can do to slow climate change,” says Hasselmann, who earned his doctorate at the former Max Planck Institute for Fluid Dynamics and helped establish the Max Planck Institute for Meteorology in 1975. “But the question is whether people understand that we have to act now in order to prevent something that will happen in 20 or 30 years’ time.”

60,000

Sediment cores from Eifel maars allow researchers to look back over 60,000 years of climate history.

EIFEL MAARS FORECAST TORRENTIAL RAINFALL

MILK MADE MIGRATION POSSIBLE

More than 5,000 years ago, the Yamnaya, a tribe of herders from the Eurasian steppe, migrated over vast areas of land. Evidence of their genes has been found in regions as far-flung as Scandinavia and Siberia. Until now, it has remained a mystery how people managed to travel such enormous distances during the Bronze Age. According to a study led by researchers from the Max Planck Institute for the Science of Human History, a dietary shift towards the consumption of dairy products may have played a key role in their migratory behavior. This is because milk contains water and important nutrients that are otherwise not often available in the steppes. The researchers sought evidence of the dietary change by examining tartar on the teeth of preserved skeletons. Before the Bronze Age, there were absolutely no signs of milk consumption, while almost all of the early Bronze Age individuals examined were found to be milk drinkers. The shift to dairy farming accordingly took place at exactly the time when the pastoralist tribes began migrating eastward. It also seems highly likely that domesticated horses played an important part in this development: the herders ate their meat, drank their milk, and used them as a means of transport.

www.mpg.de/17544984

Fewer than one hundred kilometers lie between the flood-ravaged district of Ahrweiler and the volcanic lakes (maars) in the Eifel region. These maars are now providing further evidence that extreme weather such as torrential rainfall could increase in the future. Researchers at the Johannes Gutenberg University Mainz and the Max Planck Institute for Chemistry have analyzed the layers of sediment cores from maar lakes and dry maars in the volcanic Eifel to precisely deduce how the climate in Central Europe has changed over the

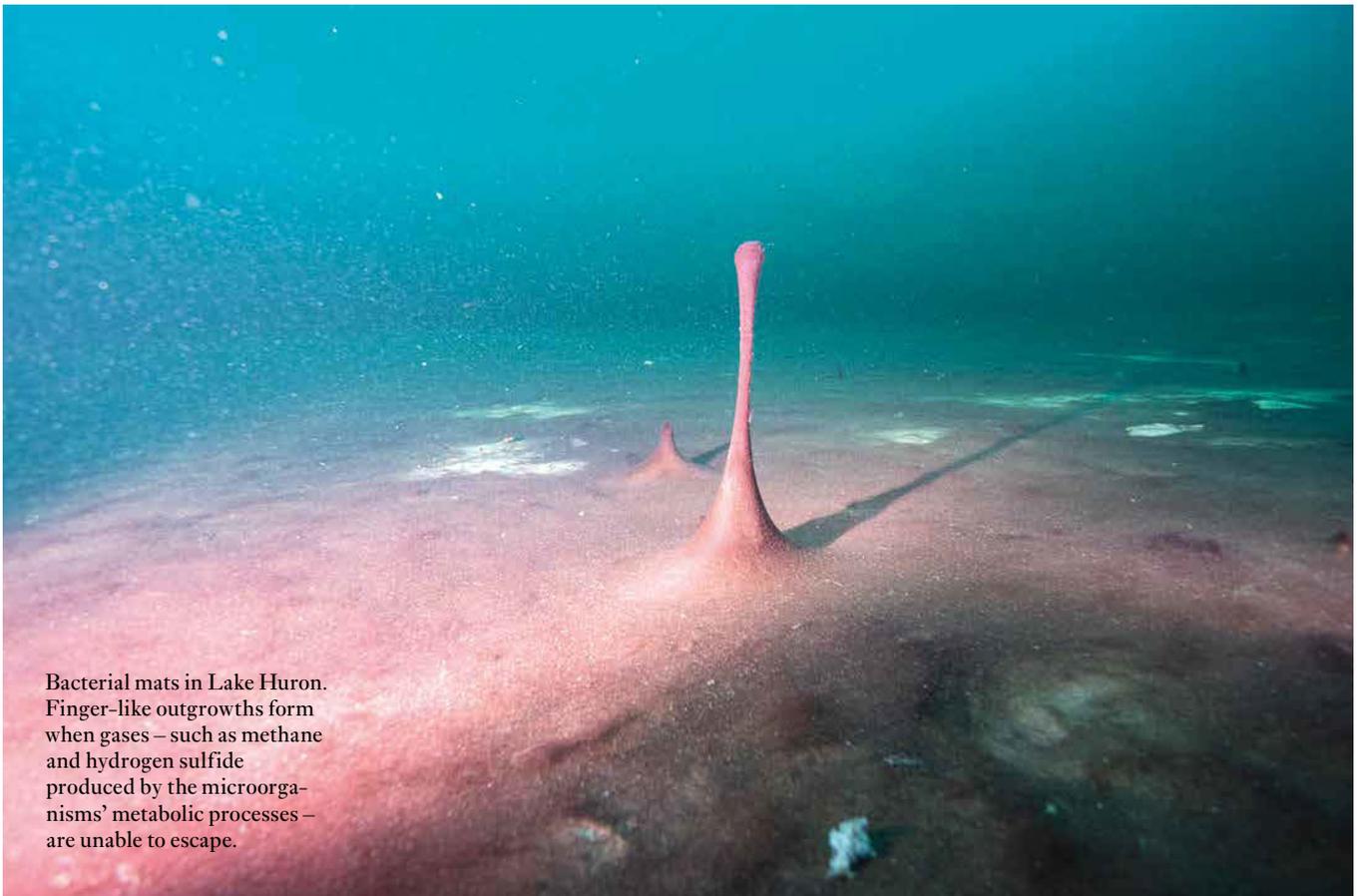
last 60,000 years. In glacial periods, the layers are very thin and barely visible. In interglacial periods, on the other hand, the layers show the course of the seasons – similar to the annual rings of a tree. In some cases, the sediment layers that formed during these phases are exceptionally thick, measuring between several millimeters and a few centimeters – this is clear evidence of flooding events. Climate fluctuations consequently appear to have been greater in these periods and the weather conditions more extreme.

www.mpg.de/03202101en

Horses in the Eurasian steppes: 5,000 years ago, herders used them as a source of milk and a means of transport for migrating to far-distant regions.



PHOTO: A. SENOKOSOV



Bacterial mats in Lake Huron. Finger-like outgrowths form when gases – such as methane and hydrogen sulfide produced by the microorganisms' metabolic processes – are unable to escape.

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PHOTO: PHIL HARTMEYER, NOAA THUNDER BAY NATIONAL MARINE SANCTUARY

A LONG DAY FOR MICROBES

Almost all of the oxygen on Earth is produced through photosynthesis, a biochemical process that is only possible in the presence of light. However, when cyanobacteria invented photosynthesis more than 2.4 billion years ago, the days were several hours shorter than they are today. They did not start growing longer until the Earth began to rotate more slowly as a result of tidal friction and the gravitational pull of the still young Moon, which at that time was closer than it is now. According to researchers at the Max Planck Institute for Marine Mi-

crobiology, the lengthening days were one factor that caused the oxygen content in the atmosphere to increase. The researchers investigated cyanobacteria in Lake Huron in Michigan, which live in conditions resembling those on the newly formed Earth. The cyanobacteria there compete with sulfur-oxidizing bacteria in the oxygen-poor waters of the lake. Every day, the microorganisms perform a little dance: while the sulfur-oxidizing bacteria form a layer above the cyanobacteria at night, the cyanobacteria rise to the surface of the microbial mat at

dawn and produce oxygen by means of photosynthesis. However, it takes a couple of hours before they really get going. Moreover, the oxygen concentration that forms between the bacterial mats and the water's surface is much weaker on shorter days, and the gas is released from the water more slowly. The increase in day length throughout the course of the Earth's history may therefore have contributed to present-day oxygen levels, thus creating the conditions for life as we know it.

www.mpg.de/17315311

NUCLEAR FUSION REACHES A MILESTONE

Nuclear fusion could open up a practically inexhaustible supply of energy. A number of competing strategies are being pursued worldwide in order to tap it, each of which has various advantages and disadvantages. The Max Planck Institute for Plasma Physics in Greifswald, Germany has now achieved one of the intermediate goals set by one of these strategies using the fusion device Wendelstein

7-X. In this – the world's largest stellarator device – scientists have optimized the magnetic cage in which the fusion plasma is enclosed, so that energy losses are significantly minimized compared with earlier devices of the same type. This means that the device now fulfills one of the requirements that must be met if it is to serve as a power plant some time in the future.

www.mpg.de/03202102en

IMAGE: MPI FOR PLASMA PHYSICS

MEMORY OF THE CORONAVIRUS

Some people have immunological memory cells that recognize the novel coronavirus SARS-CoV-2, even if they have never been in contact with it. At some point in the past, these so-called T helper cells must have had to tackle the more harmless coronaviruses that cause the common cold. A team from the Charité hospital in Berlin and the Max Planck Institute for Molecular Genetics analyzed the immune systems of almost 800 people who had previously had no contact with SARS-CoV-2. They found that the T helper cells originally produced by the body to tackle the coronaviruses that cause the common cold are also mobilized against SARS-CoV-2, thus forming a kind of cross-immunity. When faced with the more innocuous common cold, the immune system accordingly develops a kind of universal memory for all coronaviruses. This does not offer absolute protection from SARS-CoV-2, but having previously had a cold caused by coronaviruses could have a positive impact on how the disease progresses. This cross-immunity can also accelerate the effect of vaccinations: while normal T helper cells are activated step by step over a period of two weeks, cross-reactive T helper cells reacted to immunization with the Pfizer-BioNTech vaccine within just one week. However, the researchers also found that this cross-immunity declines later in life.

www.mpg.de/17434954



PHOTO: PICTURE ALLIANCE / GES / HELGE PRANG

Historic goal: in the quarter-finals of Euro 2016, Jonas Hector scored the decisive goal against Italy in the penalty shoot-out. The German team had previously won the coin toss.

COIN TOSS INFLUENCES OUTCOME OF PENALTY SHOOT-OUTS

Many fans still remember the quarter-finals of the UEFA European Football Championship in 2016. After the match went into extra time, the German team ended up in a penalty shoot-out against Italy. As usual, a coin was tossed to decide which captain would choose who would go first. Bastian Schweinsteiger won the toss for the German team and decided to let the Italian team go first – a move which many commentators saw as a mistake. They are not the only ones who cling stubbornly to the belief that shooting first puts the team at an advantage. Scientifically, however, this theory is not tenable.

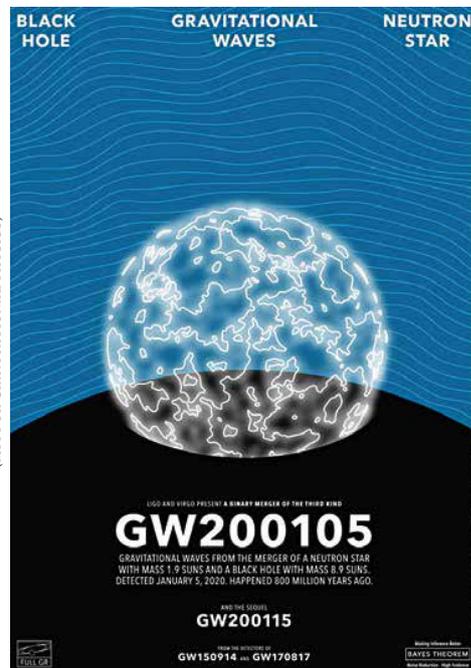
Studies have shown that the teams who shoot first only win the match about 51 percent of the time. However, a study by Matthias Sutter, Director of the Max Planck Institute for Research on Collective Goods in Bonn, and three colleagues in Duesseldorf found that the result of the coin toss did make a difference. Some 60 percent of the teams whose captains won the toss went on to win the penalty shoot-out. This is what happened in the Euro quarter-finals in 2016, which the German team ended up winning with a score of six to five.

www.mpg.de/17126111

DON'T FORGET TO TAKE BREAKS

Things we learn quickly are often soon forgotten. The same applies to mice: in an experiment conducted at the Max Planck Institute of Neurobiology, the rodents were required to memorize the location of a piece of chocolate hidden in a maze. The mice had to take breaks of varying lengths between learning phases. The animals that were given longer breaks were not able to memorize the location of the chocolate as quickly, but they did remember it for longer periods. During the test, the researchers measured the activity of neurons in the prefrontal cortex, a part of the brain involved in complex thinking tasks. The activation pattern in this part of the brain fluctuated more after short breaks than after long ones. It appears that different neurons are activated for the task if the pauses are short. After longer pauses, however, the animals again used the neurons activated in the first learning phase. Our memory may therefore benefit from the fact that connections formed between cells are strengthened after longer breaks. www.mpg.de/17302943

IMAGE: A. S. CARVALHO/A. BUONANNO, D. MIHAYLOV, J. STEINHOFF (MPI FOR GRAVITATIONAL PHYSICS)



Collisions in space: an artist's impression in the style of a movie poster depicting a black hole swallowing a neutron star. The image shows the gravitational wave events GW200105 and GW200115 – the first robust evidence of black holes merging with neutron stars.

FEAST FOR BLACK HOLES

Two cosmic disasters have occurred in quick succession more than 900 million light years away from Earth. Two black holes each engulfed a neutron star within a period of ten days – with no apparent connection between the two events. The gravitation waves emitted during these events were picked up by the LIGO and Virgo detectors. These signals are the first robust evidence of a black hole merging with a neutron star. The black holes swallowed the neutron stars in one piece. These events have allowed researchers to draw initial conclusions about how these rare binary systems form and how often they merge. “The gravitation waves come from black holes of nine and six solar masses that merged with two lighter objects of 1.9 and 1.5 solar masses respectively,” says Alessandra Buonanno, Director of the Max Planck Institute for Gravitational Physics, whose Institute was involved in the discovery and analysis of the events. The signals, named GW200105 and GW200115, were observed on January 5th and 15th respectively. www.mpg.de/16791771

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REDUCING THE CLIMATE IMPACT OF CONDENSATION TRAILS

The condensation trails (contrails) produced by aircraft have an even greater impact on global warming than their CO₂ emissions. This is because the ice crystals inside the contrails can form cirrus clouds at altitudes of about eight to twelve kilometers that have a greenhouse effect similar to that of CO₂. This climate impact can be reduced by using sustainable fuels. These are obtained either from plants or from CO₂ and hy-

drogen; they not only have a significantly better carbon footprint, but also release fewer of the soot particles on which the ice can crystallize. This means that the contrails produced by aircraft that run on a one-to-one mixture of ordinary jet fuel (kerosene) and sustainable fuel only contain half as many ice crystals as those emitted by aircraft running solely on fossil jet fuel. This discovery was made by an international team of re-

searchers from the Max Planck Institute for Chemistry in Mainz, the German Aerospace Center, and NASA. Although the ice crystals formed are larger, their smaller numbers reduce the warming effect of contrails by 20 to 30 percent. The results prove that sustainable fuels can significantly reduce the impact of aviation on climate change in the short term.

www.mpg.de/03202103en

LIFE ON VENUS? NOT A TRACE!

Venus is not a pleasant place to live. The surface is exposed to high pressure and temperatures of around 460 degrees Celsius, while violent storms rage in the dense cloud cover, which contains large quantities of caustic sulfuric acid. Could bacteria nevertheless have adapted to these extreme conditions and be surviving there? Researchers from Cardiff University in Wales believe that this is the case. They claim to have discovered tiny quantities of the trace gas phosphine in data from Venus's atmosphere received by terrestrial telescopes one year ago. This finding has sparked heated debate among experts, since the British group believes that bacte-

ria are the most likely source of the phosphine. An international team of researchers, including Paul Hartogh from the Max Planck Institute for Solar System Research, has now reviewed the original data once again – and found absolutely no indication of phosphine. Instead, the analysis revealed that sulfur dioxide, which occurs in large quantities in Venus's atmosphere, could have been mistaken for the rare gas. This is because, under the conditions on Venus, the wavelengths of certain molecules are very close together, which makes it extremely difficult to identify their fingerprints in the spectrum.

www.mpg.de/17209676



PHOTO: NASA/JPL-CALTECH

Not a haven of life: dense clouds surround Venus at an altitude of approx. 50 to 70 kilometers. There appears to be no phosphine in the atmosphere.



PHOTO: XBLICKWINKEL/AGAMI/R.MARTIN

During their fall migration, oriental honey buzzards fly more than 700 kilometers from Japan to southeast Asia. The birds wait for optimal weather and wind conditions before embarking on this 18-hour flight across the East China Sea. Using uplift enables them to soar up to one thousand meters above the sea's surface.

TAIL WIND

Flying over the open sea can be dangerous for land birds, since they cannot land on water – unlike seagulls or albatrosses, which have adjusted to life on the ocean. This means they have to cross the ocean nonstop. However, larger species in particular are unable to rely on muscular strength alone to carry them for long distances without rest. Researchers at the Max Planck Institute of Animal Behavior have been using GPS technology to track various species of buzzard, hawk, and eagle on more than one hundred long-distance flights across the open ocean, linking their flight trajectories with

global atmospheric data. The results show that the raptors take advantage of rising air masses above the water. These thermals help them conserve their energy and enable them to cover long distances nonstop. Researchers had already discovered that birds take account of wind direction when they are migrating and let the tailwinds carry them across the sea. This indicates that migratory birds only fly over large expanses of ocean if the tailwind and uplift conditions are favorable. This enables them to cover hundreds of kilometers above the open ocean.

www.mpg.de/17436480

LESS THAN PITCH-PERFECT

How good are professional singers at producing each note at exactly the right pitch? And how do they rate their own performance? This was the subject of a study by a team of researchers from the Max Planck Institute for Empirical Aesthetics in Frankfurt, New York University, and the University of Hamburg. A number of professional sopranos each recorded a vocal rendition of Happy Birthday in the studio. Afterwards, they evaluated their own recordings and those of their col-

leagues. Pitch accuracy – the ability to produce precisely pitched notes – was used as an objective measure of musical quality. Most of the participants were surprisingly inaccurate when judging their own performances, rating them too highly. However, the most proficient singers also turned out to have the most realistic opinion of their own singing. This indicates that the ability to evaluate one's own performance is a prerequisite for developing outstanding musical skills.

www.mpg.de/03202104en

ILLUSTRATION: ISTOCKPHOTO/DUNCAN1890



Striking the right note? A study revealed that mediocre professional singers often overestimate their own performance.

TAKING THE BRAIN FOR A WALK

On average, adults spend 80 to 90 percent of the day indoors – a very recent development in human evolution. This behavior is probably not particularly healthy. It has been proven that spending time outdoors has a beneficial effect on our health. Our brain structure also benefits from time spent outside, as a study performed by the Max Planck Institute for Human Development and the Hamburg-Eppendorf University Clinic now shows. This applies even if the periods spent outdoors are very brief – and regardless of whether we are in the city or the country. The results of the study show that the time which participants spent outdoors had a positive effect on the gray matter in a specific part of the cerebral cortex. This part of the cortex is involved in the planning and regulation of actions as well as behavioral control. Moreover, many psychiatric disorders are known to be associated with a reduction in the gray matter in this area of the brain.

www.mpg.de/17198632

PRECAUTIONARY MEASURES COME FIRST

Trees manage their resources differently than previously assumed. This is because they continue forming energy-rich carbon compounds even during periods of starvation, for example, during long dry spells; these compounds then serve as reserves for even worse times. To do this, the trees stop growing and, in extreme cases, may even digest their own energy-rich components. This way, the trees avoid using up all their reserves, since this would put them at risk of

starving to death in the worst case, or render them incapable of mobilizing the energy they need to fight off pests. Until now, biological research assumed that plants only build reserves when sufficient photosynthetic products are available and their growth requirements are covered. This new knowledge can now be used to improve models that predict how forests will develop as climate change progresses.

www.mpg.de/03202105en

PHOTO: MARTIN SIEPMANN/IMAGEBROKER/FOTOFINDER.COM



Thirst means death from starvation: during periods of drought, trees like these spruces in Upper Bavaria cannot produce sufficient carbohydrates. They then have to draw on reserves stored in advance.