Olfactory Code for Partner Selection

Max Planck scientists synthesize a biologically effective perfume

Humans have been using perfumes for 5,000 years. It seems they enhance the body's own olfactory signals that advertise the makeup of its immune system.

People are very picky when choosing their perfume – and rightly so, since smell plays an important role in partner selection. Humans, and probably all other vertebrates as well, obtain important information about a potential partner's immune system from their body odor. In reproduction, a partner should complement one's own immune genes, increasing their offspring's resistance to as many pathogens as possible. Scientists from the Max Planck Institute of Immunobiology and Epigenetics in Freiburg and the Max Planck Institute for Evolutionary Biology in Plön have now identified protein fragments – so-called peptides – as the biologically effective components of body odor. They have also artificially synthesized them and tested their efficacy. Female subjects always preferred a synthetic scent as a perfume for themselves if it was mixed with a peptide corresponding to their own immune gene type. These new findings make it possible to produce innovative perfumes that more effectively signal an individual's own immune gene repertoire.
(Proceedings of the Royal Society B, January 23, 2013)

Blackbirds in the Spotlight

City birds exposed to lighting at night are ready to breed earlier than their conspecifics in rural areas

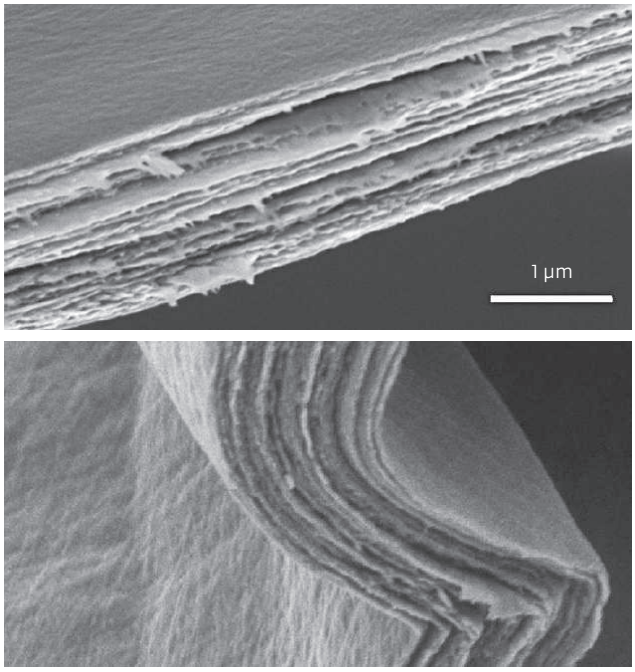
Street lamps, traffic lights and lighting from our homes are making our nights brighter and brighter. Artificial night-time illumination in our cities is thought to influence plants, animals and people. Scientists from the Max Planck Institute for Ornithology in Radolfzell recently exposed captive Eurasian blackbirds to artificial lighting at night for a ten-month period, mimicking the conditions they would encounter in an urban environment. Even weak light intensities were enough to make the blackbirds' testes mature almost a month earlier, on average. The birds also started singing about an hour earlier in the mornings. Under nocturnal lighting, the blackbirds not only showed precocious reproductive behavior, but they also molted earlier toward the end of the breeding season. Artificial light in our towns and cities can thus change the seasonal rhythm of wild animals. Next, the scientists plan to carry out field trials to find out whether early breeding gives the blackbirds an advantage, or whether it is just an unwanted side effect of life under city lights. (Proceedings of the Royal Society Series B, February 13, 2013)

Too much light: Artificial lighting at night causes male blackbirds to become sexually mature ahead of schedule, and to start molting earlier.

Photos: photocase (top left and bottom), fotolia (top right)

A Folding Ceramic

A sophisticated nanostructure gives strength and pliability to a wafer-thin paper made of electroconductive vanadium pentoxide fibers



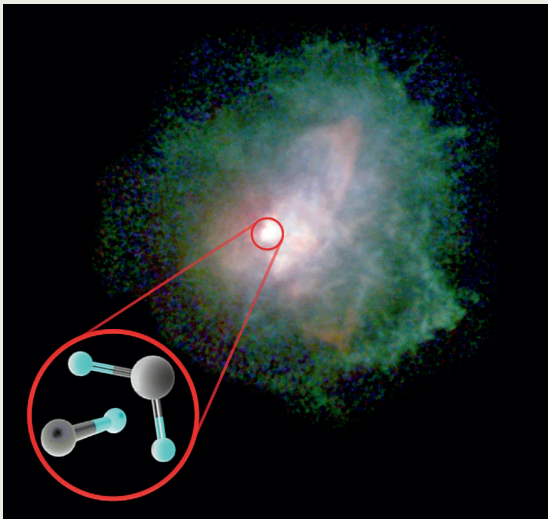
Researchers in Stuttgart are currently doing things to a ceramic that would normally reduce it to a pile of shards. In an innovative process, they used a vanadium pentoxide ceramic to make a paper as tough as copper but flexible enough to be rolled up and folded. The material also differs from other ceramics because it conducts electricity. Žaklina Burghard and her team at Stuttgart University and the Max Planck Institute for Intelligent Systems coated a carrier material with an aqueous film containing finely distributed vanadium pentoxide nanofibers. They then made sheets of the ceramic by drying the film and treating it with moderate heat. The ceramic paper owes its special mechanical properties to its mother-of-pearl-like structure. Potential applications include using it as an electrode material for thin, flexible batteries. Since the ceramic's conductivity changes if molecules are incorporated between its layers, the paper could also act as a gas sensor.
(Advanced Materials, March 7, 2013)

Layered ceramic paper: Scanning electron micrographs show the stacked layers of vanadium pentoxide and water. The material is so elastic and tough that it can be bent (bottom).

Sun Block for a Big Canine

Astronomers discover titanium oxide and titanium dioxide around the giant star VY Canis Majoris

An international team led by researchers at the Max Planck Institute for Radio Astronomy and the University of Cologne has identified two titanium oxides in the extended atmosphere surrounding a mighty star. The object, VY Canis Majoris, has a diameter 1,000 to 2,000 times that of our Sun and is one of the largest known stars of all. This giant sun is nearing the end of its life: as it does so, it is blasting out huge quantities of material from its surface, forming an irregular dust cloud, or nebula. Astronomers studied the nebula with telescope arrays in the USA and France, and detected titanium oxide (TiO) and titanium dioxide (TiO_2) at radio wavelengths for the first time. One of the uses for titanium dioxide is as an ingredient in sun block. This discovery should help us understand the process by which dust is formed around stars.
(Astronomy & Astrophysics, March 4, 2013)

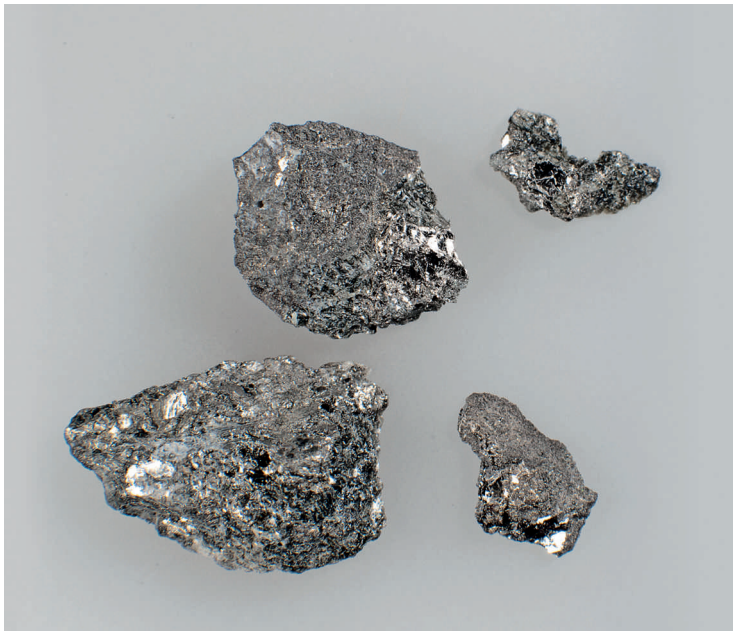


Gone with the stellar wind: An extensive dust nebula surrounds VY Canis Majoris in the constellation Canis Major. Astronomers found the molecules TiO and TiO_2 in this giant star's atmosphere.

Photos: Advanced Materials – Stuttgart University (top); molecular symbols: CDMS/T. Kaminski; background image: NASA/ESA and R. Humphreys (University of Minnesota) (bottom)

A Nanoelectronics Gold Mine

The mineral kawazulite is a member of the class of topological insulators, which are of interest as materials for use in spintronics



Nature's treasure trove contains much more versatile materials than previously thought. A team headed by Marko Burghard at the Max Planck Institute for Solid State Research in Stuttgart has now discovered that the mineral kawazulite is a topological insulator. These materials conduct electricity only on their surface. They are of interest to applied science because the route of electron flow on the surface is directly associated with their spin direction. This spin equals the direction of the electrons' rotation around their own axes, and gives them a magnetic moment. It has potential applications in nanoelectronics, to allow efficient storage and processing of information in a very tight space. So far, physicists have only synthesized topological insulators in the lab by order, according to precisely calculated formulas. It now turns out that they are also formed naturally in more or less random mixtures, at a quality that is at least as good as in the lab.
(Nanoletters, February 26, 2013)

Quantum properties for a shining example: The interior of the natural mineral kawazulite insulates against electric current; it is conductive only on its surface.

Photos: MPI for Solid State Research (top), Wikimedia Commons (bottom)

Toxins Return from the Depths

In the middle depths of the sea, concentrations of chemicals that are harmful to our health and the environment can continually rise even though their use by man has been declining for decades

A few particularly unpleasant toxins are likely to present problems to humans and the environment longer than was once thought. As discovered in a simulation by researchers at the Max Planck Institute for Chemistry and at Hamburg University, appreciable concentrations of DDT and polychlorinated biphenyls (PCBs) are still circulating through the oceans at depths of 200 to 1,500 meters. This is happening even though emissions of DDT have been decreasing since around 1966, and those of PCBs since the early 1970s. The atmosphere, bed and surface waters of the sea have also seen falling pollution levels for some time because the substances initially move from the air into the sea, and then sink from its surface into deeper layers. For example, transport by ocean currents has caused two transient sharp rises in the concentration of PCB153 off the west coast of Ireland at depths of 700 to 1,200 meters, the first happening in the period around 1985, and the second around 2000. Through the food chain and deep-sea fishing, these poisons (which also have the potential to cause cancer) can come back from the middle depths of the ocean to harm human health.
(Geophysical Research Letters, April 15, 2013)

US soldiers demonstrating delousing with DDT in the 1940s. The toxin has seen far less use since then.

Navigating along Earth's Magnetic Field

European robins have to learn their navigation charts as juveniles

In winter, some of Central Europe's robins migrate to Italy, Portugal, France and Spain, while animals from northern and eastern Europe come to Germany to overwinter.

In spring and fall, thousands of birds move to their summer and winter quarters, respectively. Their flight path is genetically determined, but birds also possess a sense of direction that uses the Earth's magnetic field for guidance. According to scientists from the Max Planck Institute for Ornithology in Radolfzell, juvenile birds develop magnetic maps during their first migrations, and use them to find their way around in subsequent years. The researchers exposed both inexperienced juvenile European robins and their older counterparts to a strong magnetic pulse, temporarily disrupting their sense of magnetism. Afterward the seasoned travelers found orientation more difficult. It seems that the pulse reset the robins' magnetic maps. Because of this, they had to rely on other information from the environment, and flew the wrong way. In contrast, the juvenile birds, which were setting out on their first annual migration and had not yet built up a magnetic map, didn't lose their bearings.

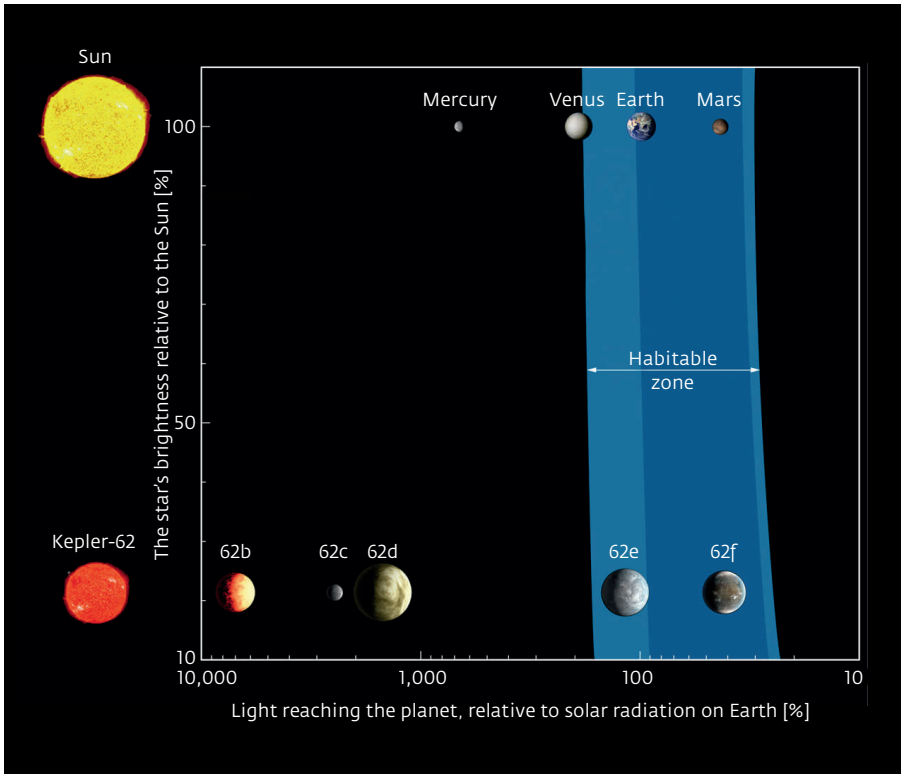
(Journal of the Royal Society Interface, February 6, 2013)

Two Second Earths

Habitable conditions are thought to exist on two exoplanets in the constellation of Lyra

The search for a second Earth has guided the hunt for extrasolar planets. Most of the heavenly bodies discovered in this context so far are either too big or orbit too close to their sun. An international team including Lisa Kaltenegger from the Max Planck Institute for Astronomy in Heidelberg has now discovered two likely candidates: Kepler-62e and Kepler-62f. Their radii are 1.61 and 1.41 times that of the Earth, meaning that they are very likely to be rocky planets with a solid surface. Both planets also orbit in the habitable zone where liquid water can occur – the prerequisite for life as we know it. The star Kepler-62 lies in the Lyra constellation. It is about 1,200 light-years away and a little smaller and cooler than the Sun. Seen from our point of view, the planets pass in front of their host star at regular intervals, blocking a fraction of its light. This phenomenon is exploited by the transit method, the technique used by the *Kepler* space telescope to discover these objects.

(Science, April 18, 2013)



Habitats: The habitable zone, where liquid water can exist on a planet's surface, for various types of stars. The inner planets of our own solar system are shown above; of these, Earth and Mars lie in the habitable zone. Kepler-62 is much cooler than the Sun, and Kepler-62e and 62f orbit in its habitable zone.

Photos: iStockphoto (top), MPI for Astronomy – Lisa Kaltenegger

Australians with a Migration Background

Long before Europeans settled in Australia, humans migrated there from the Indian subcontinent and interbred with the Australian Aborigines

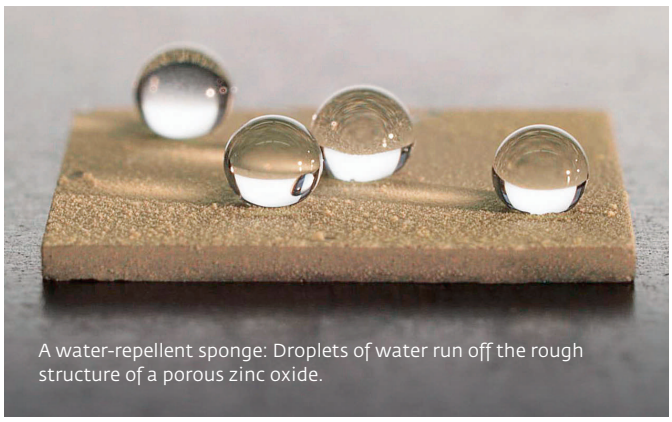
Modern humans settled in Australia relatively late. The earliest archeological evidence for their presence dates back just 45,000 years. The sea level in those days was lower than it is now, and Australia and New Guinea formed a single land mass known as Sahul. It was long assumed that there was no further contact between Australia and the rest of the world until the Europeans arrived in the 18th century. However, scientists at the Max Planck Institute for Evolutionary Anthropology in Leipzig analyzed variations in the genome of Australian Aborigines, Indians and inhabitants of New Guinea and the islands of Southeast Asia. According to their findings, there was substantial gene flow from India to Australia 4,230 years ago. This means that humans must have migrated to Australia from the Indian subcontinent. The gene data fit in with abrupt changes in archaeological finds. Apparently these immigrants brought with them new plant processing and stone tool manufacturing techniques. The dingo, a type of dog that went back to the wild many millennia ago, also makes its first appearance in Australia at this time. (PNAS, first published online, January 14, 2013)

Australia lost its Ice Age link with the mainland some 4,000 years ago. The new settlers from the Indian subcontinent must therefore have crossed the ocean by boat.

When Is a Film Not a Film?

It's easy to predict when a liquid will spread out over a surface in a thin film and when it will form droplets

In extreme cases, whether water moistens a surface or not can be a matter of life or death: examples include water films that freeze on a road surface, or that coat insulators in transformer stations and cause them to short out. As Stephan Herminghaus, Director at the Max Planck Institute for Dynamics and Self-Organization in Göttingen, discovered, it's very easy to predict the conditions under which a liquid will form a continuous layer on a realistic surface, such as a wall or floor, and when it will run off it in droplets. According to his findings, just two key parameters determine the outcome: the vapor pressure of the liquid in the surrounding air, and the contact angle between the liquid and the surface, which depends on the substances involved. To date, it has been possible to make these predictions only for completely smooth surfaces and for those on which more or less regularly aligned grooves served as a rather unrealistic model of roughness. In contrast, the formula derived by Stephan Herminghaus applies to most surfaces with randomly distributed peaks and troughs at heights ranging from a few nanometers to approximately one millimeter. It also makes it possible to produce tailor-made materials with specific wetting properties.
(Geophysical Review Letters, December 5, 2012)



A water-repellent sponge: Droplets of water run off the rough structure of a porous zinc oxide.

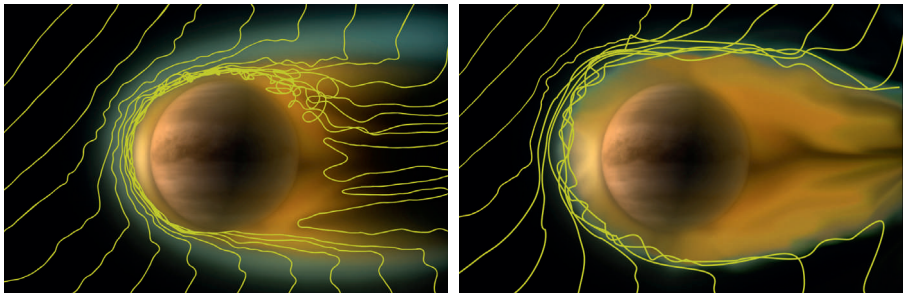
Photos: Gunter Senft (top), MPI for Metals Research (bottom)

The Tail of Venus

When the solar wind runs out of steam, our neighboring planet's ionosphere reaches a long way into space

On its dark side, Venus's ionosphere can spread out into space like a tail at least 15,000 kilometers in length. This deformation occurs when the solar wind – a continuous flow of electrons and protons – comes to a near-standstill. Scientists working under the direction of the Max Planck Institute for Solar System Research studied this kind of event closely for the first time with the aid of the European space probe *Venus Express*. Electrons and ions stream from Venus's day side to the side facing away from the Sun; the high plasma pressure on the day side drives this flow. Normally, magnetic fields hold the charged ionosphere particles close to the planet. However, when the solar wind is weak, the ionosphere becomes stretched in the transitional region between the day and night sides. Consequently, the charged particles move more easily and in greater numbers to the night side. A kind of plasma balloon is formed there and fans out into space like a tail.

(Planetary and Space Science 73, 2012)



A gas trail in space: Under normal conditions, the ionosphere surrounding Venus is at an altitude of 150 to 300 kilometers. The induced magnetic fields – as indicated by the yellow lines – hold it in place there (left). When the solar wind is very weak, the ionosphere is able to expand. This forms a kind of plasma tail on the planet's night side (right).

Growth without Limits?

The stagnation in global population predicted by the UN won't last

Ten billion people will be it – at least that is the United Nations' prediction for world population growth by the end of the century. "However, the UN's upper limit is anything but stable," says Oskar Burger from the Max Planck Institute for Demographic Research in Rostock. From their model-based calculations of the global population, Burger and his colleagues concluded that a brief period of stagnation will indeed occur when the ten-billion mark is reached, but that the world's population will then begin to grow sharply again. Energy supply is the main reason for this. With a lower supply of usable energy, economic development declines, resulting in a rise in birth rates. In other words, population size would remain stable only if sufficient energy per capita continued to be available. However, we can hardly expect this to be the case. "Since 1960, the population has grown at a faster rate than the worldwide supply of usable energy," says Burger.

Stepping Stones on the Ocean Floor

Animals and microorganisms can use wood fragments deposited in the deepest oceans to cross the enormous distances between nutrient-rich vents and seeps

Trees don't grow in the far depths of the ocean, but a tree trunk that has sunk to the seabed can still become a Noah's Ark for deep-sea inhabitants. A team including researchers from the Max Planck Institute for Marine Microbiology in Bremen deposited logs on the floor of the Eastern Mediterranean at a depth of 1,700 meters. A year later, they found them to be populated with a multitude of bacteria and animals. The main colonizers of the wood were a type of wood-boring bivalves also known as ship-worms. These shellfish of the genus *Xylophaga* form the vanguard, preparing the habitat for the species that follow. They need bacteria to help them digest the wood. Breaking down wood uses up oxygen, enabling sulfate-reducing microorganisms to produce hydrogen sulfide. The researchers also found a mussel species that uses sulfur as an energy source and is normally found only at cold seeps. Thus, the life forms inhabiting the deep sea can use foreign material such as uprooted trees, as well as torn-off seaweed strands and sunken whale cadavers, to cross distances of hundreds of kilometers between cold seeps.

(PLoS ONE, January 2, 2013)

Photo: ESA/Wie et al. (2012)

Electronics Comes to Paper

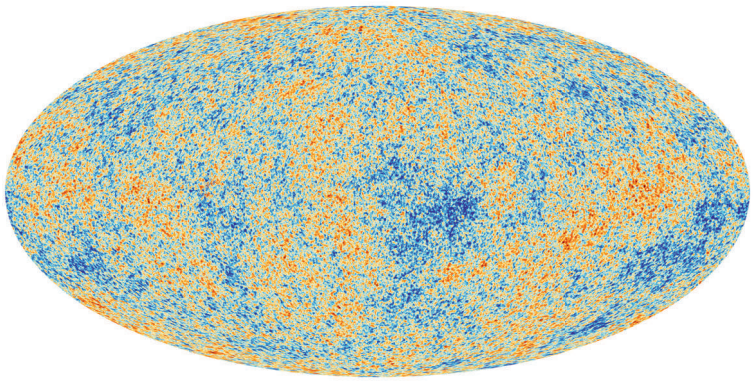
This light, foldable raw material can be used to generate electrically conducting structures in a simple, low-cost process

Paper is getting to be a high-tech material. Cristina Giordano and her fellow scientists at the Max Planck Institute of Colloids and Interfaces in Potsdam-Golm have created light and flexible conductive structures on paper with a very simple technique: using a standard inkjet printer, they applied a catalyst to a sheet of paper and then heated this sheet in a nitrogen atmosphere. This caused the printed areas to turn into conductive graphite, while non-conductive, amorphous carbon formed on the catalyst-free areas. When the scientists folded the paper prior to this catalytic conversion, they also got three-dimensional conductive structures. In an airless environment, carbon-based electronics are much more heat resistant than plastics, which are currently used for flexible chips. As a result, the former are easier to integrate into the processes used in the semiconductor industry, which run at temperatures in excess of 400 degrees Celsius.
(Angewandte Chemie Int. Ed., January 17, 2013)

Minerva electrified: Researchers from Potsdam used paper to produce conductive graphite in the shape of the Max Planck Society logo. The scientists then gave Minerva an electrolytic copper coating.

A Near-Perfect Universe

The *Planck* satellite provides a detailed image of background cosmic radiation to confirm the conventional model of the universe, while also revealing inconsistencies



Baby photo of the universe: The irregularities in background cosmic microwave radiation, as observed by *Planck*. The map shows tiny temperature fluctuations in regions of slightly different density, representing the seeds of stars and galaxies.

The first full sky map of background microwave radiation confirms the standard cosmological model and establishes its parameters with great accuracy. Thus, according to observations made by the *Planck* satellite, the universe was born in the Big Bang 13.82 billion years ago, making it a little older than previously thought. It is also expanding at a slightly slower rate. And a bit of adjustment is needed as regards the composition of the universe: it is made up of 4.9 percent ordinary matter (galaxies, stars and planets), 26.8 percent dark matter and 68.3 percent dark energy. However, the European satellite also found significant anomalies: The fluctuations in radiation on large scales are smaller than might be expected from structures measured on smaller scales. Moreover, the northern and southern celestial hemispheres appear to have differing structures, as evidenced by a cold spot in the southern sky that extends over a much larger area than expected.
(Astronomy & Astrophysics, March 22, 2013)

Genes without Templates

Copying is easier than inventing something new – this principle was long thought to apply to the evolution of genes, as well. Accordingly, the established view is that evolution made multiple copies of existing genes and then adapted them to new tasks. However, according to scientists from the Max Planck Institute for Evolutionary Biology in Plön, genes are often made from scratch, from previously unread segments of the genome. Their analyses of the genes of mice, humans and fish have revealed that young genes are often shorter than those that have been around for longer. Moreover, these younger genes possess fewer regions that are translated into amino acids, known as exons. It seems that new genes need time to collect more exons. The findings obtained by the scientists in Plön indicate that about 60 percent of genes originate from our single-celled ancestors in the early phase of evolution. Particularly large numbers of new genes were introduced with major evolutionary innovations, such as the big leap from single- to multi-celled organisms and the advent of vertebrates.
(BMC Genomics, February 21, 2013)

Photo: ESA and Planck Collaboration (top), MPI of Colloids and Interfaces (bottom)