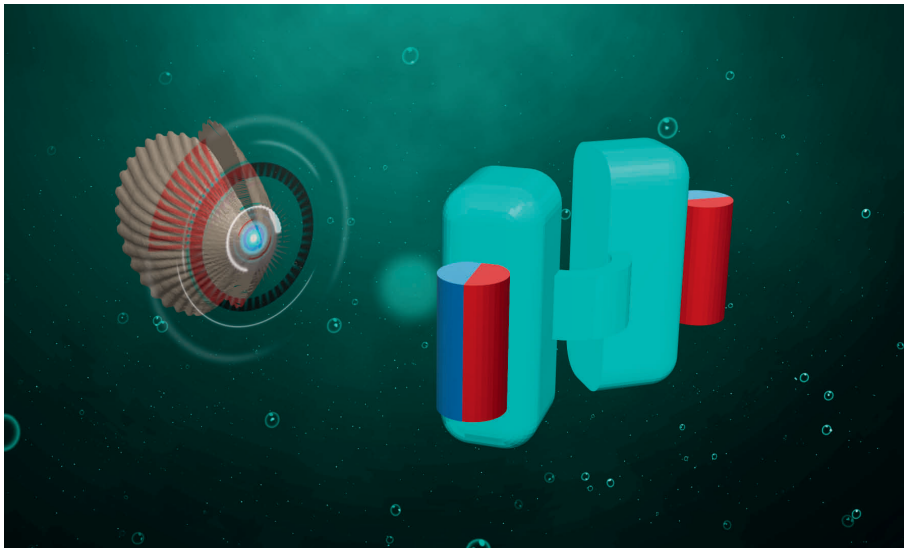
Micro-Scallops for Medical Applications

Tiny swimmers can be propelled through media resembling bodily fluids

Micro- or even nano-robots could someday perform medical tasks in the human body. A team of researchers, including members from a group led by Peer Fischer from the Max Planck Institute for Intelligent Systems in Stuttgart, have now taken a first step toward this goal. They have succeeded in constructing a type of artificial scallop measuring just a few hundred micrometers in diameter. The scientists navigate the tiny vehicle through biological fluids by using a magnetic field to rapidly open and close the device. This kind of locomotion is possible only because the viscosity of the model fluids – like that of bodily fluids – changes with the device's speed of movement. The micro-shell can be propelled not only by a magnetic actuator, but also by one that responds, for example, to temperature changes. Previously, the Stuttgart-based researchers presented a corkscrew-shaped nano-vehicle that moves like a propeller through a liquid medium. (Nature Communications, November 4, 2014, & ACS Nano, published online on June 9, 2014)

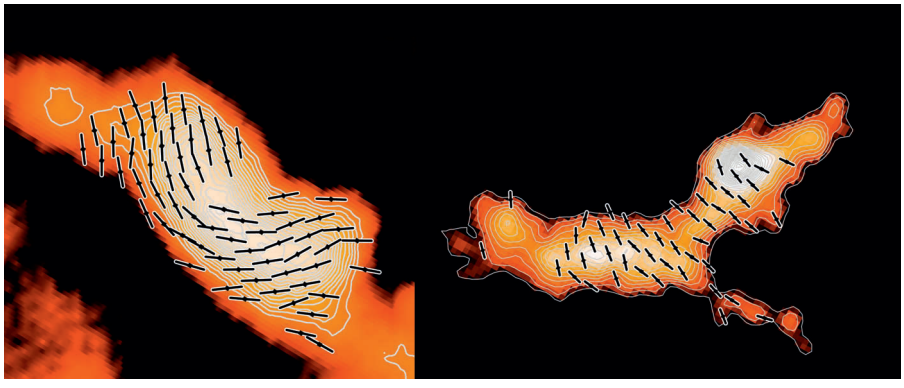


Scallop-shaped micro-swimmers: Basing their design on the operating principle of this shellfish species, a team of Max Planck researchers in Stuttgart has built a tiny submarine, shown in this image on the right. Small magnets, shown here as red and blue cylinders, open and close the two halves (shells) of the device.

Magnetic Fields as Midwives for Stars

Astronomers observe polarized dust emission of two dark clouds in the Milky Way

Stellar heavyweights in the universe, with eight or more times the mass of the Sun, form from very dense and massive gaseous cores deeply embedded within interstellar clouds. In fact, the high mass of these cores has long puzzled researchers: due to their own gravity, the cores should – in theory – quickly collapse and self-destruct before telescopes on Earth can detect them. So what prevents them from collapsing? A team headed by researchers from the Max Planck Institute for Radio Astronomy in Bonn has now found the answer: the experts observed polarized dust emissions from two of the most massive clouds in our Milky Way, the "Brick" and the "Snake." They discovered that strong magnetic fields hold the clouds together and help stabilize the region while it gets ready to form high-mass stars. (Astrophysical Journal , vol. 799, 2015)



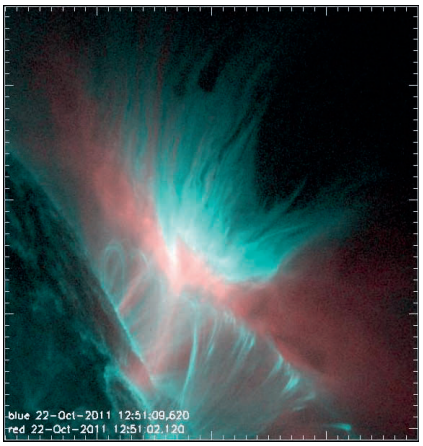
Brick and Snake: The left panel shows the "Brick." The white contours indicate the emission of cold dust. The right panel shows a magnification of the densest section of the "Snake." The arrows indicate the orientation of the magnetic field as deduced from polarization observations.

Photos: T. Pillai & J. Kauffmann, based on GLIMPSE & MIPSGAL images from the Spitzer satellite (NASA/JPL-Caltech/Univ. of Wisconsin) and the Hertz polarimeter at the CSO (J. Dotson) (bottom); Alejandro Posada/MPI for Intelligent Systems (top)

The Dark Fingers of the Sun

Computer models solve the enigma of mysterious structures in solar eruptions

The Sun is constantly bubbling, and in this process, finger-like plasma structures lasting several minutes form in the Sun's gaseous envelope, the corona. These structures appear whenever gas masses are ejected from the Sun's surface at extremely high velocities. Ever since they were discovered around 15 years ago, researchers have been trying to unravel the mystery surrounding the forces that create these dark structures known as "tadpoles"; they form a clear contrast to the bright plasma in which they are embedded and which is visible in ultraviolet light. A German-American team of scientists headed by the Max Planck Institute for Solar System Research has now succeeded in finding an explanation for these filigree shapes. The scientists analyzed images of the Sun, but also created computer models that simulate the formation of these plasma structures. Their findings show that the driving force behind this phenomenon is a fundamental process in fluid physics known as the Rayleigh-Taylor instability. The RTI can occur when plasmas of different densities come together. (Astrophysical Journal Letters, December 1, 2014)



A witch's cauldron in the solar atmosphere: This image originates from the AIA instrument of the American *SDO* satellite and shows the ultraviolet radiation emitted from part of the corona on October 22, 2011. It was taken at a wavelength of 13.1 nanometers (turquoise) and 9.4 nanometers (red). The dark, finger-like structures of the Rayleigh-Taylor instability at the top of the image stand out clearly from the bright plasma.

Collision of Two Galaxy Clusters

The catalogs of celestial objects list a galaxy cluster called "Abell 4067." However, recent observations using the *XMM-Newton* space observatory indicate that this object actually constitutes a merger of two separate clusters. The smaller system appears to be losing the majority of its gas. The data analyzed by scientists at the Max Planck Institute for Extraterrestrial Physics also shows that the compact core of the infalling cluster has thus far survived this encounter. The core cuts right through the central region of the larger galaxy cluster like a bullet, without being destroyed in the process. The layers outside of the core, however, are stripped away. Further observations are scheduled in the near future to examine this process in detail and study how the gases of the two components mix. From this, the researchers hope to gain new insights into the growth of galaxy clusters in general. (Astronomy & Astrophysics, January 10, 2015)

Photos: MPI for Evolutionary Anthropology/R. Barr (bottom); NASA/SDO/MPS (top)

Don't Be an Outsider!

Toddlers imitate their peers to fit in – great apes stay true to themselves

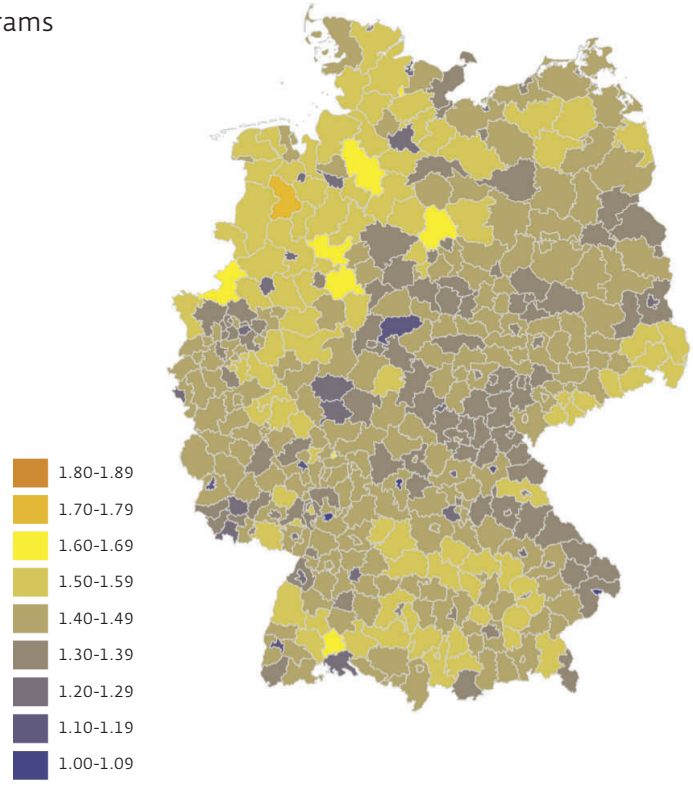
From the playground to the boardroom – people often adapt their behavior to those around them in order to fit in with a particular group. Even children as young as two years of age give in to peer pressure: a study conducted by the Max Planck Institute for Evolutionary Anthropology in Leipzig has shown that, even at such a young age, children forego a reward if it means having to behave differently from their peers. Chimpanzees and orangutans, on the other hand, mostly ignore the actions of their peers, even after reaching adulthood, and instead stay true to themselves. Conformity is thus a typically human trait, and a very useful one at that, as it delimits different groups. By adapting their behavior, humans can coordinate joint activities. Furthermore, conformity stabilizes and fosters cultural diversity. (Psychological Science, October 29, 2014)

Even children as young as two experience peer pressure and imitate other kids to fit in.

More Daycare Centers Doesn't Always Mean More Children

Stable cultural influences can hinder family policy programs

In Germany, the birth rate is around 1.39 children per woman – on average. Because in reality, the birth rate varies significantly from region to region, and this has been going on for decades: there is no unified trend among couples across the country deciding for or against children. The conclusion "more daycare centers = more children" or "more money = more children" doesn't automatically hold true in all parts of Germany. In fact, as Barbara Fulda from the Max Planck Institute for the Study of Societies discovered, gender roles and model families are perceived differently in different regions, which might explain the varying success of sociopolitical programs designed to incentivize couples to start a family and have more children. These cultural influences became apparent in a field study conducted as part of her dissertation, in which she compared two regions in the German states of Baden-Wuerttemberg and Bavaria, which have similar sociocultural backgrounds. These influences supplemented factors that are commonly studied in fertility research, like the number of available places in kindergartens and the financial conditions related to starting a family. Cultural influences, however, change very slowly. This could explain why the regional differences in birth rate remain so stable, and why these discrepancies lead to the fact that family policy incentives – such as parental allowances for fathers – aren't as widely accepted in all parts of the country as policy makers would like them to be.



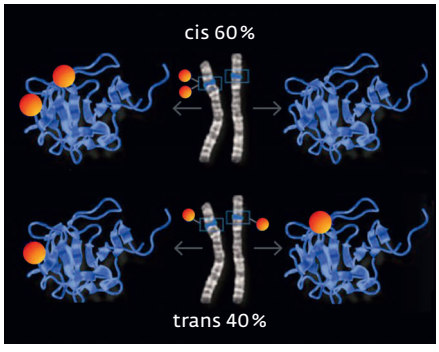
Birth rate in Germany by region for 2011. In some cases, the birth rate varies drastically from region to region.

Duality in the Human Genome

Our genomes are extraordinarily individual – a challenge for personalized medicine

Humans don't like being alone, and neither do their genes, which prefer instead to occur in pairs. However, conventional analytical methods can detect only a mix of the maternal and paternal forms of a gene. Scientists at the Max Planck Institute for Molecular Genetics in Berlin analyzed the genetic makeup of several hundred people and decoded the genetic information on the two sets of chromosomes separately. A sample of this size contains an average of 250 different forms of each gene. In larger sample sizes, the number of possible forms increases accordingly. Changes in a gene form that cause an amino acid in a protein to be exchanged for another are known as mutations. When several mutations occur in a single gene, these mutations aren't randomly distributed between the parental chromosomes, as the researchers discovered: in 60 percent of the cases, all of a gene's mutations occur in just one of the parental chromosomes, while in 40 percent of the cases, they occur in both. The diversity decreases at the protein level, yet in 372 test subjects, most of the genes and their numerous forms still produce at least 5 to 20 different protein forms – a major challenge for scientists seeking to develop customized treatment methods that target individual proteins.

(Nature Communications, November 26, 2014)



Every human being possesses cis and trans mutations in a 60:40 ratio. In the cis configuration, two or more mutations occur in either only the paternal or only the maternal copy of the gene. The copy without mutations then serves as a blueprint for an undamaged protein. In the trans configuration, however, both copies of the gene are mutated, meaning they both produce damaged proteins.

Photos: Art 4 Science (bottom); INKAR 2011, GADM database (top)

Look First

Visual perceptions dominate conversations

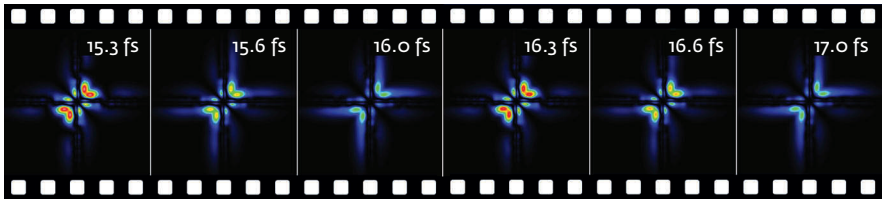
When people converse with each other, they often speak about what they hear, smell, taste or feel. First and foremost, however, they talk about their visual perceptions. Sight is the most important of the five senses, and the respective verbs dominate the conversations. This is the conclusion reached by a team headed by researchers from the Max Planck Institute for Psycholinguistics after conducting a study involving 13 languages from around the world. The scientists analyzed audio and video recordings of typical everyday conversations. However, they found no evidence of a fixed hierarchy of the other four senses in the speakers' linguistic usage. Hearing ranked second in most of the languages studied, but in Semai, for example, which is spoken on the Malay Peninsula, verbal references to olfactory impressions occur more frequently than allusions to hearing. Why we most frequently talk about sight and visual perceptions may be because of the specific biology of the human sensory apparatus, and because there are simply more opportunities for visual experiences than, say, taste experiences. After all, you can look at many things, but you can't go around tasting everything. (Cognitive Linguistics, December 23, 2014)

Chatting at the hairdresser's: Here, too, visual perception is the subject of casual conversation much more often than anything related to hearing, smelling, tasting or touching.

Choreography of an Electron Pair

The motion of the two particles in a helium atom can be imaged and controlled with precisely timed laser flashes

Physicists are continuously advancing the control they can exert over matter. A German-Spanish team headed by researchers from the Max Planck Institute for Nuclear Physics in Heidelberg filmed the motion of the two electrons in a helium atom for the first time, and even controlled this electronic partner dance. The scientists managed to do this using a series of different, precisely timed laser pulses. For this, they employed a combination of visible flashes of light and ultraviolet pulses that lasted just a few hundred attoseconds. One attosecond is one billionth of a billionth of a second. One of the reasons physicists aim to specifically influence the motion of electron pairs is because they want to revolutionize the field of chemistry: if they can steer the paired bonding electrons in molecules using laser pulses, they could potentially create substances that can't be produced using conventional chemical means. (Nature, December 18, 2014)



Electronic pas de deux: Using attosecond pulses, physicists in Heidelberg filmed an electron pair moving for 1.7 femtoseconds (fs) (1 fs is one millionth of one billionth of a second). At 15.3 femtoseconds (fs), both electrons are close to the nucleus (center of image) and then move away from it. At 16.3 femtoseconds, they arrive back at their original position.

Photos: MPI for Nuclear Physics (bottom); MPI for Psycholinguistics (top)

Smiling Builds Trust

Smiles perceived as genuine promote cooperation

A smile says more than a thousand words: By smiling, people signal trustworthiness and their willingness to cooperate.

"A smile gains more friends than a long face." This Chinese proverb holds true, however, only if the smile is sincere and genuine. Researchers at the Max Planck Institute for Evolutionary Biology in Plön conducted a behavioral experiment that proves that such a Duchenne smile creates trust. A Duchenne smile is formed subconsciously and is considered to be outside of our voluntary control. The study carried out by the researchers from Plön shows that a smile rated as honest and genuine induces trust, and rightly so: on average, those individuals are more cooperative. The study also shows that a person is more likely to produce a genuine smile when the stakes are high and the matter at hand is important to that individual. It therefore seems that flashing a Duchenne smile is costly, and the associated effort is made only if it is deemed worthwhile. (Evolution and Human Behavior, January 2015)

Obesity – Like Father, Like Son

A parent's diet can lead to epigenetic changes that affect their offspring's bodyweight

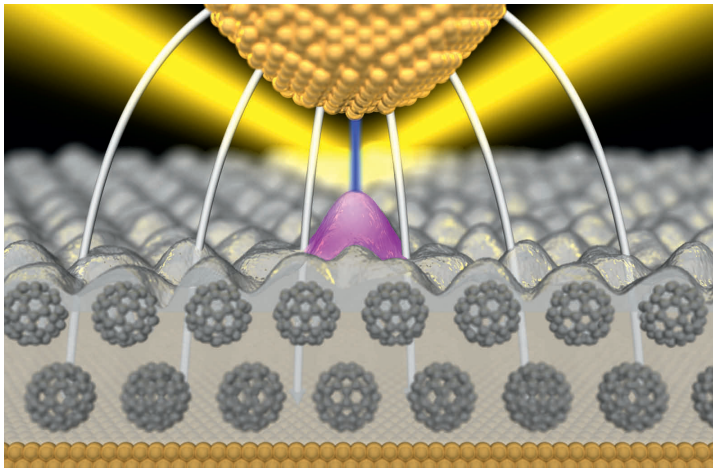
Our genes are a major factor in determining our weight. At the same time, however, environmental influences can also affect bodyweight through what are known as epigenetic changes. These modifications can be inherited, although they don't change the genetic code. Scientists at the Max Planck Institute of Immunobiology and Epigenetics in Freiburg discovered that the diet of male fruit flies can influence the bodyweight of their sons in this way. The offspring whose fathers were fed food with a very low or very high sugar content two days before mating tended to be overweight – but only if they themselves also consumed large amounts of sugar. The fathers' diet had no impact on sons that consumed a balanced diet. The offspring of fathers that weren't conditioned by a very low- or high-sugar diet, on the other hand, maintained a normal bodyweight even if they consumed large amounts of sugar. The researchers believe that if fathers are fed a high-sugar diet, the packaging of the DNA in their sons is loosened, allowing fat metabolism genes to be expressed more easily. A similar mechanism may also exist in humans: the evaluation of data from tests on North American Pima Indians, who frequently suffer from obesity, shows that obese humans have the same gene signature as the fruit flies. (Cell, December 4, 2014)

Researchers can identify the obese flies by their red eyes: Due to the particularly sugary diet of their fathers, the genes for a red dye in the eyes, as well as for other metabolic factors, can be detected in the sons.

Photos: MPI of Immunobiology and Epigenetics/A. Pospisilik (bottom); svetlkd/iStock (top)

A Nano-Lamp with a Lightning-Fast Switch

A light source and its transistor-operated brightness control shrink to the size of a single molecule

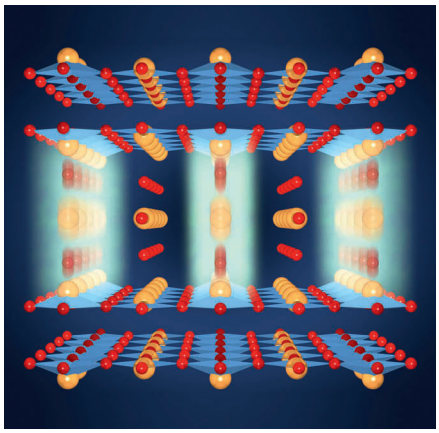


Information is processed and transmitted by ever-smaller components, sometimes using electrons and sometimes using light. Scientists at the Max Planck Institute for Solid State Research in Stuttgart have now developed a light source that converts an electrical voltage pulse into a light pulse by means of a single organic dye molecule. In this process, the molecule generates light and also functions as a transistor-controlled light switch, which can even be used to regulate the light intensity by means of the voltage that is applied. Since the molecular switch allows the light to be switched on and off extremely quickly, this light source could serve as a blueprint for nano-components that convert electrical signals with gigahertz frequencies into optical signals.
(Nano Letters, published online on September 2, 2014)

Researchers at the Max Planck Institute for Solid State Research first coat a gold surface with a layer of spherical carbon molecules and then place a single dye molecule (shown here in magenta) on it. Next they apply a voltage between the prepared surface and the tip of a scanning tunneling microscope, creating an electric field (indicated by the gray lines in the diagram). At a specific field strength, the dye molecule converts the electrical energy into light (shown here as a yellow wave).

Superconductivity without Cooling

The electrical resistance of some materials can be removed not only by means of extremely low temperatures, but also – albeit for a very short time only – by using intense infrared laser pulses. An international team, to which physicists from the Max Planck Institute for the Structure and Dynamics of Matter in Hamburg made crucial contributions, has now explained how the light makes a ceramic called yttrium barium copper oxide superconducting even at around 20 degrees Celsius. According to the team, the laser pulses cause individual atoms in the crystal lattice to briefly shift, thus enabling superconductivity. These findings could help scientists develop materials that become superconducting at significantly higher temperatures, and that would therefore be of interest for new applications.
(Nature, December 4, 2014)



No resistance at room temperature: Short light pulses excite oxygen atoms (red) in the copper oxide ceramic, causing them to briefly oscillate (blurred). As a result, the distance within each copper oxide double layer increases (copper – yellow-orange), while the distance between the double layers simultaneously decreases. It is highly probable that this effect enhances the superconductivity.

Photos: MPI for the Structure and Dynamics of Matter/Jörg Harms (bottom); MPI for Solid State Research (top)

Computer-Based Brain Games Fail to Deliver on Their Promise

"Train your brain by playing games." That sounds too good to be true – and in fact, it probably is just that. This advertising slogan wants us to believe that we can enhance our cognitive abilities and even prevent dementia by playing certain "brain games." Yet there is no scientific evidence to support these claims, as 70 internationally renowned cognitive psychologists and neuroscientists have now clarified in a joint statement. There aren't enough research findings to suggest whether and how these games affect the brain and cognitive performance, or help individuals cope with day-to-day activities. Yet the human brain and behavior can be trained well into old age even without computer games: people who remain physically active, take part in social activities and lead intellectually stimulating lives stand a better chance of staying mentally fit as they age.