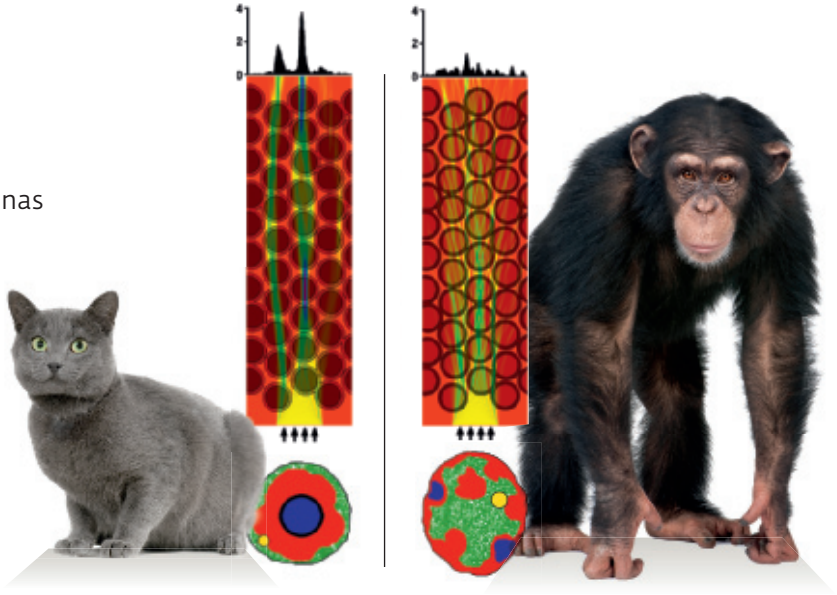
Cell Nuclei Act as Lenses

DNA in an unusual arrangement in the retinas of nocturnal mammals focuses light



Not only are nocturnal mammals, such as cats, able to dilate their pupils particularly widely, but the cell nuclei in the rod receptor cells in their retinas are constructed so that they focus light.

Photos: iStockphoto (2); illustration: a collage of the images in the CELL article

When every photon counts, nature resorts to unconventional methods. A team of researchers including scientists from the Max Planck Institute for Brain Research found that cell nuclei in the retinas of nocturnal mammals, or more precisely in the rod receptor cells, are built to function as collecting lenses.

The inside of these nuclei is densely packed with genetic material that strongly refracts light. This material, called heterochromatin, does not have a function in this particular area and thus does not need to be accessible to enzymes. The heterochromatin is enclosed by loosely massed and thus less refractive eurochromatin, which contains the necessary genetic information. In this architecture, the cell nuclei focus the light. In every other mammalian cell, and also in the rods of diurnal animals, the nuclei are arranged in exactly the opposite way, with the usable areas of DNA on the inside and the unused DNA on the outside. This architecture scatters the light, which is then lost, but the arrangement must also have benefits that have not yet been recognized. (Cell, April 17, 2009)

A Water Bath Promotes Order

If only it were always so easy to achieve neatness: Nanospheres treated with a technique developed by researchers at the Max Planck Institute for Polymer Research arrange themselves of their own accord.

The scientists produce the tiny plastic spheres in an emulsion of water and styrene, dry them, and subsequently return them to the water. Then the spheres suddenly float up to the surface, where they rearrange themselves neatly. It is not yet known why this happens. Because the spheres are very cohesive, the researchers are able to coat any object with a crystalline layer simply by submerging the object in the water and removing it again.

This technique can be used to create membranes with pores of a specific size: coatings of very small spheres can render screens non-reflecting, and a layer of slightly larger particles would repel water and dirt with the lotus effect.

(Macromolecular Chemistry and Physics 2009, 210, DOI:10.1002/macp200800484)

Out of the water, into the water: Plastic spheres prepared in an emulsion and then dried (left) are resubmerged in water (center) and can then be removed from the water in an ordered layer (right).

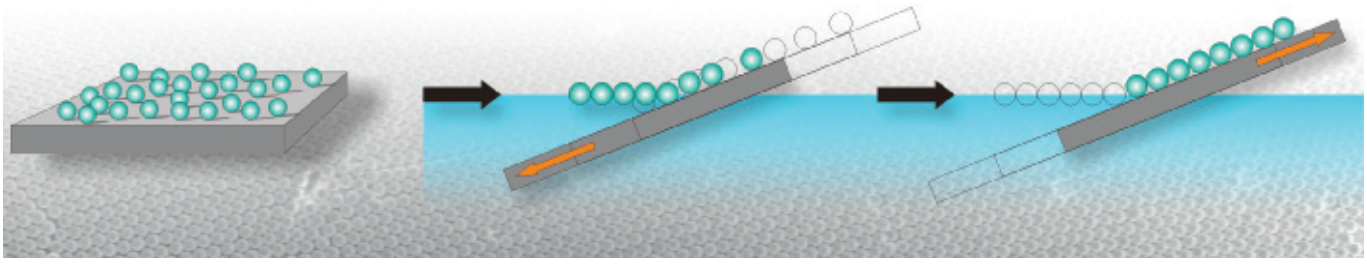


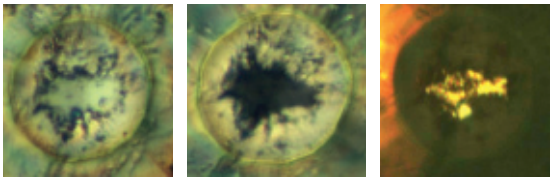
Illustration: MPI for Polymer Research

Glassy, Not Glossy

Under very high pressure, sodium ceases to be a metal and becomes transparent

Scientists at the Max Planck Institute for Chemistry have obtained a clearer view of the properties of metals. Working as part of an international team, they put sodium, which under normal conditions has a silvery sheen and a toffee-like consistency, under extremely high pressures.

At two million bar, which is two million times greater than the pressure of the Earth's atmosphere, the sodium shrank to a fifth of its original size and became transparent, resembling yellowed glass. Calculations performed by the partners in this cooperative venture also indicate that it probably loses its other metallic properties as well. This would mean that it would no longer conduct a current, nor would it be malleable. It would thus no longer qualify as a metal at these high pressures. Physicists previously believed that conductivity increases as pressure rises. Now it appears that this is true only up to a certain point. (Nature, March 12, 2009)



At atmospheric pressure, sodium is shiny and silver (left); at just under one million bar, it turns black (center), and at two million bar, becomes transparent, like yellowed glass. The change in color can be seen in the center of each of the three images.

Photos: MPI for Chemistry

Competition Stimulates the Breeding Process

Blue tit females feed their young more food if they previously had to compete with others for a limited number of nesting places. Furthermore, those that do find a breeding place where opportunities to nest are at a premium produce more male offspring. Some of the females that are left homeless behave like cuckoos and lay eggs in the nests of their rivals. Researchers at the Max Planck Institute for Ornithology observed these changes in breeding behavior in a long-term study during which they removed a number of nest boxes from the Wienerwald woods around Vienna, Austria. It was not possible to establish whether the competition encourages the successful females to make more effort, or whether these females are more successful per se because they naturally invest more in caring for their brood. Nor has it been fully explained how the birds influence the gender of their offspring. It might possibly be achieved with raised levels of testosterone. (Animal Behaviour, March 4, 2009)

Even blue tits can struggle to find a home. However, females who have beaten the competition to a nesting place feed their offspring more.

Photos: iStockphoto/alimdi.net

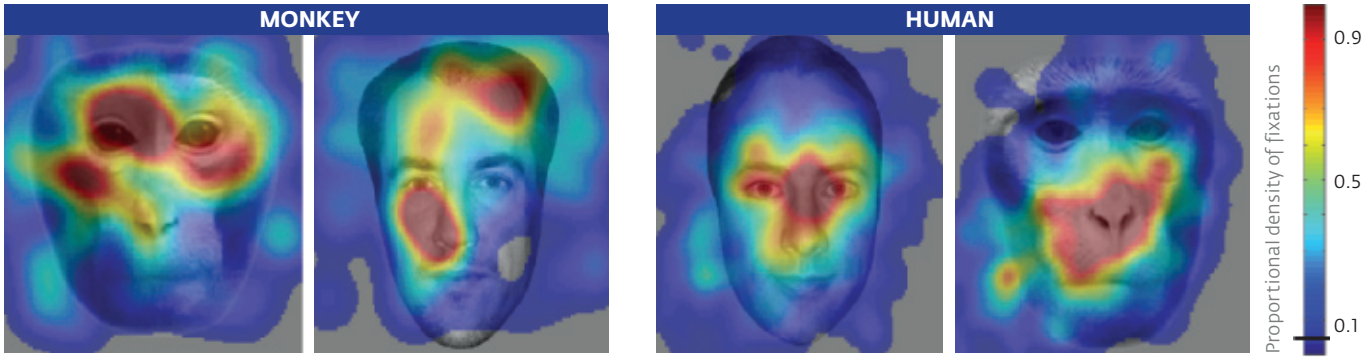
A Stuttering Gene

It was pure chance: Some thale cress (*Arabidopsis thaliana*) plants placed in a growing room heated to 27 degrees Celsius failed to thrive. Searching for the cause of this failure led scientists at the Max Planck Institute for Developmental Biology to a surprising discovery. In these ailing plants, a gene required for photosynthesis was found to have a defect that also causes certain neurological diseases in humans.

The DNA of this gene contains over 400 consecutive repetitions of a three-base sequence. In healthy control plants, the same sequence, called a triplet, occurs only 20 times. This triplet stuttering means that the gene can no longer be read correctly and translated into functional proteins. What makes this observation really interesting is that similar gene defects are the cause of some serious hereditary neurodegenerative diseases in humans, such as Huntington's Chorea, which is characterized by increasing motor dysfunction and dementia. Investigating the genes of the thale cress plant could thus shed some light on the genetic causes and development of serious hereditary diseases in humans.

Here's Looking at You, Fellow!

Humans and monkeys are experts in face recognition among their own species



Photos: MPI for Biological Cybernetics

When looking at a member of their own species, rhesus monkeys and humans first concentrate on the eyes. In the analysis of their eye movements, red indicates a high density of looks. In contrast, when they look at another species, their gaze does not rest on a particular feature.

Monkeys do not look at each other at all differently from the way humans do: rhesus monkeys first look members of their own species in the eye. However, by analyzing their eye movements, researchers at the Max Planck Institute for Biological Cybernetics discovered that they allow their gaze to wander aimlessly over human faces. Similarly, when humans encounter each other, their eyes meet first, whereas they scan the face of a monkey more haphazardly. This study demonstrates yet another similarity between humans and monkeys. It is not yet clear though what benefits are to be had from processing the faces of conspecifics differently from those of other species. (Current Biology, February 26, 2009)

Data Stored on Iron

A network of iron atoms and organic terephthalate acid molecules on a copper substrate holds the promise of providing extremely dense data storage solutions. Made by scientists at the Max Planck Institute for Solid State Research in Stuttgart, this network might prove suitable for storing data because the spin of individual electrons in their shell makes the iron atoms behave like tiny magnets, which are normally oriented completely randomly. This is not the case in the metal-organic framework on the copper substrate, where the atomic iron magnets are all aligned horizontally, lying flat, as it were. The real point is that it is possible to exert some influence over such a flat-lying magnet. When oxygen settles on the iron atoms, the spins adopt a vertical orientation. It has been shown that this principle allows the iron atoms to flip between two states, thus enabling them to be used to store binary data. However, this currently works only when the temperature is close to absolute zero.
(Nature Materials, March 2009)

Deciding direction: In a network of iron and an organic acid, the magnetic moment of an iron atom under an oxygen molecule is vertical (top). Without the oxygen on top, it lies horizontal along the plane of the network (bottom). The large image was taken with a scanning tunneling electron microscope; the sections illustrate the chemical structure (green – iron; black – carbon; white – hydrogen and red – oxygen).

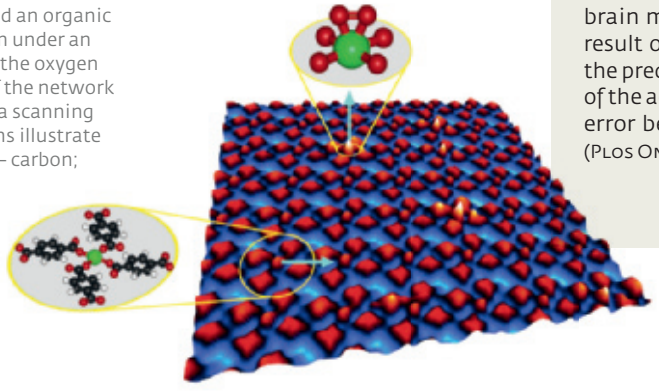


Illustration: MPI for Solid State Research

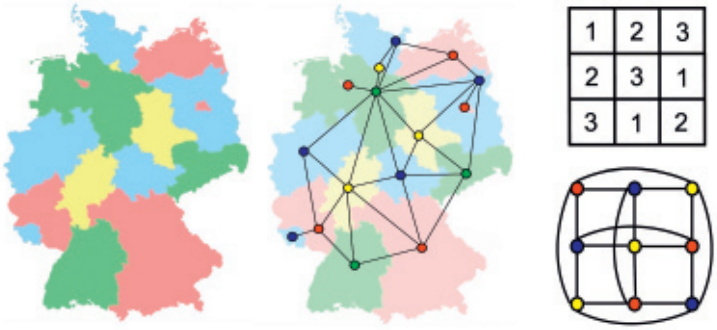
An Alarm System in the Brain

When a pianist hits the wrong key, his or her brain has already registered the error, even before the wrong note sounds. Researchers from the Max Planck Institute for Human Cognitive and Brain Sciences and from the University of Sussex made this discovery when they took EEGs of a number of pianists. Measurements showed that they registered an error one tenth of a second before they hit the wrong key. Furthermore, they pressed the key less forcefully and with a delay – presumably in a vain attempt to correct the error. It is likely that the brain makes predictions about the result of an action quite early on. If the prediction is contrary to the goal of the action, the brain discovers the error before it has even happened.
(PLoS One, April 1, 2009)

Step by Step Across the Map

A new computer algorithm is solving previously unsolvable counting problems

It appears that, when seeking ways to color a map so that adjacent countries are shown in different colors, it pays not to look too far ahead: scrutinizing the map like a short-sighted person, looking at just one section at a time, will achieve this objective more quickly. Researchers from the Max Planck Institute for Dynamics and Self-Organization are solving problems of this kind much more quickly than with traditional methods, which always look at the whole problem, an entire map, for example. Physicists, mathematicians and computer scientists often look for the number of possible combinations, not only for the colors on a map, but also to describe the properties of a solid or to find the number combinations in a Sudoku puzzle. In many cases, the new algorithm is the only way to find the solution, because conventional methods often prove too slow for practical application. (New Journal of Physics, February 4, 2009)



Possible variations: A map of Germany and a Sudoku puzzle with three rows of three boxes (right) depicted as networks with different-colored nodes.

Illustration: MPI for Dynamics and Self-Organization

Photo: MPI for Chemical Ecology – Hubert Herz

Ants Use Anti-Fungal Toxins for Protection

Leaf-cutting ants have long been doing what doctors do: they fight harmful fungi with such substances as candicines, which are also used in medicine to treat fungal infections. Scientists at the Max Planck Institute for Chemical Ecology have isolated the substances from some types of bacteria with which the ants have a symbiotic relationship. This arrangement allows the insects to protect their cultures of *Leucoagaricus gongylophorus* from a harmful fungus. The *Leucoagaricus gongylophorus* fungus is food for the ants, and they cultivate it carefully on pieces of leaf. If they were not able to rely on medical help from the bacteria, the *Escovopsis* fungus would destroy their food supplies. (PNAS, March 24, 2009)

Gardeners and their fungus supply: A leaf-cutting ant with a fragment of leaf on which the insects cultivate a fungus for food.

The Germ Cell of a Galaxy

The young universe was a very lively place: Scientists at the Max Planck Institute for Astronomy have found a positively explosive rate of star formation in a distant galaxy that can be seen from Earth at the "young" age of barely one billion years. Every year, stars with a total mass of more than 1,000 solar masses are formed there over an area measuring 5,000 light-years in diameter.

In comparison, our Milky Way, which extends over 100,000 light-years, produces on average one star of one solar mass every year. The astronomers who made this observation also solved an unanswered question about how galaxies are created. It appears that the star boom in a young galaxy starts in a small, central area and then gradually spreads out. It was previously thought possible that stars were formed throughout the galaxy at the same rate right from the beginning. (Nature, February 5, 2009)

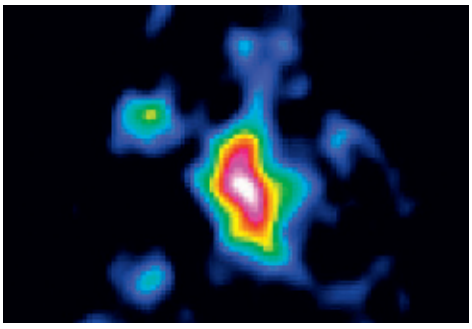
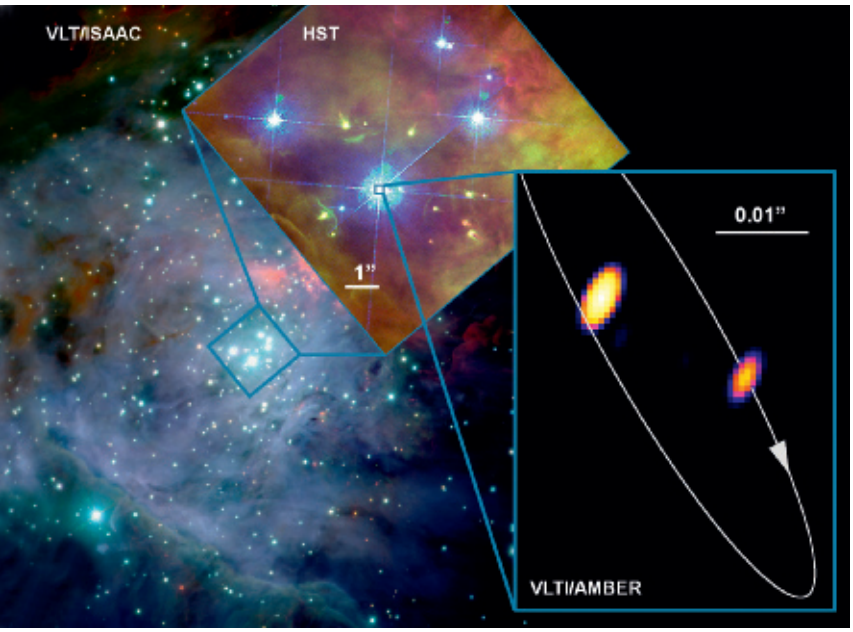


Photo: NRAO/AUI/NSF

A view of a fast breeder for stars: False-color image of galaxy J1148+5251, taken with the radio telescopes of the Very Large Array in New Mexico.

An Automobile on the Moon …



Theta 1 Ori C (right) in the center of the Orion nebula turned out to be a double star when it was viewed in an image of previously unachieved clarity created by the VLT interferometer.

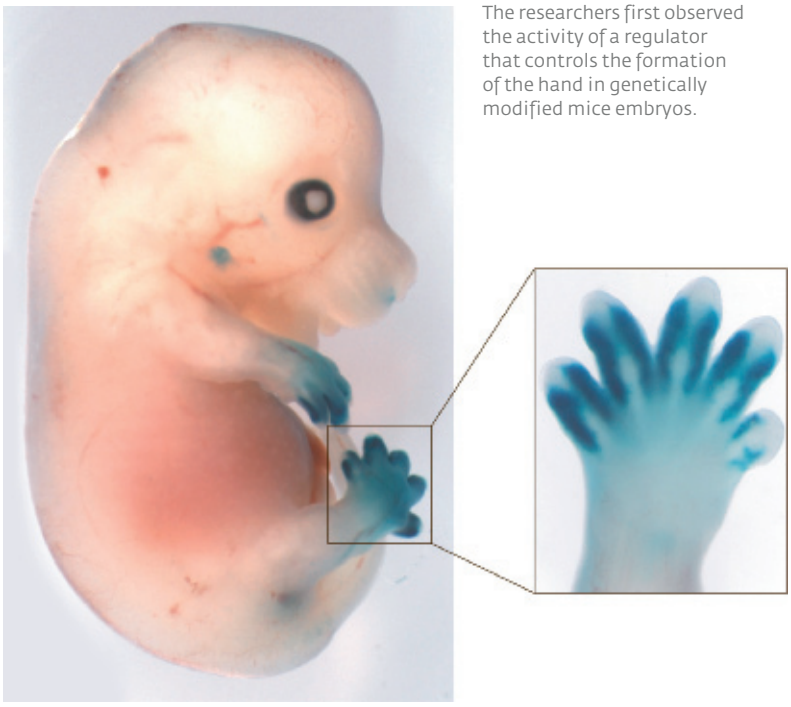
… would be visible only through a telescope with a mirror that measured 200 meters in diameter. From Earth, it would appear only at an angle measuring some two-millionths of a degree – comparable to viewing a one-euro coin from a distance of almost 4,000 kilometers. However, this clarity has been achieved with a new measuring technique developed by an international team working under the guidance of researchers from the Max Planck Institute for Radio Astronomy in Bonn. They used the *Very Large Telescope Interferometer* at the European Southern Observatory with a piece of equipment that combines the beams (in the near infrared spectrum) from several individual telescopes into a very clear composite image. The astronomers chose Theta 1 Ori C as their target. This is the most massive and brightest star in the central Orion nebula to appear through conventional telescopes, such as the Hubble Space Telescope, as a single star. But the new technology allowed the researchers to demonstrate that it is, in fact, accompanied by a much dimmer star. The mass of the larger star is 38 solar masses, while that of its companion is 9 solar masses.
(Astronomy & Astrophysics, now in print)

Photo: MPIfR/Stefan Kraus, ESO und NASA/Chris O'Dell

Duplicate Genes Cause Short Fingers

Our hands are one of Nature's masterpieces, and are the tools with which we grasp the world. Their development in the embryo is already very complex. Scientists at the Charité University Hospital in Berlin and the Max Planck Institute for Molecular Genetics, also in Berlin, working with colleagues from Hamburg, Cologne, Denmark and Brazil have now uncovered another part of the complicated process that controls this development.

They found that type 2 brachydactylia, a genetic abnormality in which the middle bone of the index finger is shortened or missing entirely, is caused by a tiny duplication of non-coding genetic sequences. Near the duplication, a regulator is found that controls a gene, BMP2 (bone morphogenetic protein 2), that is crucial for the formation of the hands and fingers. What is surprising is that the duplication is in a sequence of the genome that occurs almost identically in several different species, including chickens and mice, and has therefore hardly changed at all in the course of evolution. (American Journal of Human Genetics, April 10, 2009)



The researchers first observed the activity of a regulator that controls the formation of the hand in genetically modified mice embryos.

Photo: MPI for Molecular Genetics

Musical Emotion Knows No Boundaries

Joy, sadness and fear can all be recognized in piano music, even if the listeners are not familiar with Western music

The essence of music is to express emotion and to evoke emotion in the listener. But how does a person who has never heard Western music react to the unfamiliar sound? Or, to put the question another way, are humans born with the ability to understand the emotions in music, or do they acquire an ear for this through experience?

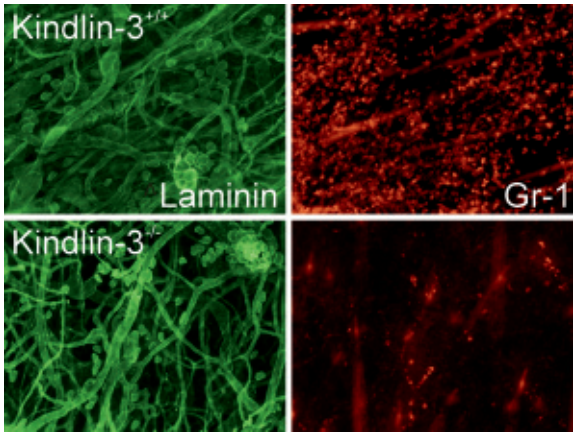
Scientists at the Max Planck Institute for Human Cognitive and Brain Sciences have now come a big step closer to answering this question, having conducted experiments with the Mafa tribe, native to the Mandara mountains in Cameroon. Although these people had never heard Western music, they clearly identified happiness, sadness and fear in piano music. They tended to perceive music with fast tempos as happy, but sadness or fear depended largely on whether the music was composed in a major or a minor key. Like listeners with a Western background, the Mafa also preferred consonance, but were slightly more tolerant of dissonance.
(Current Biology, online, March 19, 2009)

Moved by Western music: These two Mafa women took part in Thomas Fritz's study.

Photo: MPI for Human Cognitive and Brain Sciences

Loose Blood Cells

White blood cells that are unable to penetrate infected tissue can't fight pathogens, which is why infections escalate in patients with the rare genetic disease LAD III. The culprit is a defect in a gene identified by researchers at the Max Planck Institute of Biochemistry. It contains the blueprint for the kindlin-3 protein, which activates an anchor protein on the surface of white blood cells. The defect in the kindlin-3 gene prevents the immune cells in the blood from reaching the infected tissue. Previously, a different genetic defect had been suspected of causing LAD III. Now that the real cause has been identified, it will be possible to develop therapies.
(Nature Medicine, February 22, 2009)



Photos: MPI of Biochemistry – M. Moser

Access guide for white blood cells: With kindlin-3 (top), normal leukocytes (red) rapidly move from the blood vessels (green) into the infected tissue (top right). Without kindlin-3 (bottom), they are unable to do this (bottom right).

Money or Conscience?

Attempts to motivate consumers to buy an environmentally friendly automobile should appeal to their feelings rather than their pockets. If politicians offer financial incentives too soon, they may undermine the success of information campaigns. Researchers at the Max Planck Institute of Economics and at the Technical University in Zurich asked 1,581 potential car buyers which political measures would be effective in reducing carbon dioxide emissions. According to their findings, only a small proportion of buyers are sufficiently enlightened, but these people are opinion leaders and drive technological progress, creating a democratic basis so that the environment can also benefit from financial measures. This is because customers who make a financially motivated decision to purchase a vehicle also need a minimum of ecological awareness. Otherwise they might believe that, by paying more, they were buying the right to damage the environment.
(Ecological Economics, March 2009)