We have to climb a mountain in order to conquer it. In quantum physics, however, there is a different way: instead of laboriously climbing over it, objects can reach the opposite side of a hill by simply tunneling through it. An international team of researchers working with Ferenc Krausz from the Max Planck Institute for Quantum Optics has now observed electrons in this tunneling process for the first time. They watched how electrons escaped the attraction of an atomic nucleus. Using ultra-short laser pulses, the scientists proved the existence of discrete levels of ionization, each of which lasts a few hundred attoseconds, or a fraction of a quadrillionth of a second. The results will make a significant contribution to better understanding how electrons move in atoms and molecules. (Nature, April 5, 2007)

Siynipho’s problem was one of physics. The stone he incessantly rolled up the mountain was pulled back down to the valley again and again by gravity, only coming to a halt at the lowest point because that is where its energy was least. In physics, this means that it stopped moving at the minimum of the potential created by gravity. This principle became a curse for the mythical Sisyphus, but it is what holds our world – and more precisely, the atoms of our world – together.

It pulls every particle to the deepest point of a potential – even electrons. The negatively charged particles try to reach the lowest point of the binding potential created by the electrostatic force of the positively charged atomic nucleus. As the electrons move very quickly, they do not collapse into the nucleus, but circle around it at a respectable distance. They are trapped in an electrostatic potential wall slightly with a strong red laser field, some of the electrons broke through it. “Our findings confirmed, for the first time in real-time observation, the theoretical predictions of quantum mechanics,” says Ferenc Krausz, Director at the Max Planck Institute for Quantum Optics and head of the team of scientists.

According to the laws of quantum mechanics, an electron can tunnel because it is a wave as well as a particle. Therefore, there is a certain probability that it will be somewhere where, according to the laws of classical physics, it should not be – in a potential wall, for example, or even on the other side of the wall. However, the likelihood that a macroscopic object, such as a boulder, would get to the other side of a mountain in the same way is infinitesimally small – which is why no one has yet observed a tunneling boulder. On the other hand, the chances that microscopic particles will manage to wangle their way through mountains, albeit electrostatic mountains, are pretty good. However, not only electrons escape the attraction of their nucleus by tunneling. Alpha particles, too, detach themselves from radioactive nuclei in this way, and atomic nuclei tunnel toward each other in the fusion process. Although the tunneling effect is not rare in nature, it has not yet been possible to observe it in real time because it simply happened too quickly. Krausz and his team have now seen it live with the aid of light.

The experiments not only allow us insight into the dynamics of electron tunneling,” says Krausz. “We have also shown that the movement of electrons in atoms or molecules can be observed in real time with laser-field induced tunneling. The physicists use these findings to control the movement of the electrons. “In the future, this will allow us to find out how the boundaries of microelectronics can be moved,” says Krausz. Optical electronics works more efficiently the more precisely the interaction between light and electrons is controlled. It might even be possible for physicists to develop compact X-ray lasers if they have more influence over the electronic processes in atoms. Such brilliant X-ray sources would allow better images of biological objects or improvements in radiation therapy.

If you would like to know more about the team’s research, check out the website of the Max Planck Institute for Quantum Optics, Garching: www.mpq.mpg.de.
Why do cresscens bloom in the spring and asters in the fall? And why are the flowers always found on the top of the shoots and not anywhere else on the leaves or stems? Plants actually have molecular light sensors in their leaves that measure the seasonal differences in day length. At the right time, usually in the spring, the leaves send a messenger substance as a signal to induce flowering. The question of what this florensin actually is has provided work for generations of botanists. Progress was first seen in the late 1990s and in 2005, and the issue of how the florensin reaches the shoot tips has proved a particularly controversial subject.

George Coupland and his team at the Max Planck Institute for Plant Breeding Research in Cologne were able to show that the protein FT (florigen) moves from the leaves to the shoot tips of the plant, and not the associated mRNA. The question remained of how the FT protein is indeed formed in the leaves, subsequently traveling through the whole plant to the growing points in the tips, where flowering is induced. Further proof of the fact that it is the FT protein that triggers flowering, and not the associated mRNA, is supplied by an experiment with Arabidopsis mutants that do not create an FT protein, as they then do not have the relevant gene. These mutants were crossed with normal Arabidopsis plants. The researchers have now observed how the FT protein moves from the lower plant through the grafted FT-free plant, and how flowers then formed. Nevertheless, not all scientists believe that the experiments provide sufficient proof. And so the final chapter in the florescent story is yet to come.

The florensin FT is a protein that was tagged with green fluorescent protein (GFP) and observed in the vascular tissue of an Arabidopsis (mouse-ear cress) seedling under a microscope. This experiment revealed that the FT protein moves from the leaves to the shoot tips of the plant.

How Molecules Shake Hands

Life is teamwork on a grand scale: there are more molecules working away hand-in-hand in the human body than there are stars in space. An international team of scientists including re-searchers from the Max Planck Institute for Solid State Research has now observed how molecules recognize their partners in this joint venture. Using a scanning tunneling microscope, they observed how two chiral dipeptide mole-cules joined together to form a pair. Like many molecules, these molecules occur in our body in two forms that are mirror images of each other and that, like our right and left hands, cannot be perfectly superimposed on each other. In order for the dipeptides to be able to form stable pairs and for biomol-eccules to be able to support life processes, mole-cules must be able to recognize those with the specific complementary form. The scientists discovered that the molecules modify themselves slightly during this recognition process, like two right hands enclosing each other. (Nature Reviews, June 11, 2007)

Some 10^{27} molecules in nearly a hundred thou-sand different forms make up the molecules we are. Each molecule carries structural information. "This information determines which molecules work together to make the body function," says Magali Lingenfelder, one of the Max Planck re-searchers involved in the study, "because they take place only when the right-handed or left-hand-ed molecules recognize each other. As in a handshake, however, it is not sufficient for two molecules with the same chira-lity to fit together. Chemists refer to this joining of right-hand-ed or left-handed molecules as chiral recogni-tion. "It is highly significant for many processes in our body," says Giovanni Costantini, who was also involved in the study, "because they take place only when the right-handed or left-hand-ed molecules recognize each other. As in a handshake, however, it is not sufficient for two molecules with the same chiral form to meet; they must also adapt themselves to fit to the other. In a handshake, however, it is not sufficient for two molecules with the same chiral form to meet; they must also adapt themselves to fit to the other. In a handshake, however, it is not sufficient for two molecules with the same chiral form to meet; they must also adapt themselves to fit to the other. In a handshake, however, it is not sufficient for two molecules with the same chiral form to meet; they must also adapt themselves to fit to the other."

An important aspect of this information is stored in the chirality. This term is derived from the Greek word for hand and describes molecules that exist in two forms, like hands: the left-hand-ed and the right-hand-ed form. The two cannot be brought into spatial congruence. Using the hand image, either the palms or the backs of the hands are touching, or the thumbs point in different di-rections. In a handshake, only two right or two left hands fit together perfectly. In exactly the same way, only two molecules with the same chi-rality fit together perfectly.

The scientists from the Max Planck Institute for Solid State Research made image sequences of this process with a scanning tunneling mi-croscope. The films reveal that molecules only recognize other molecules with the same chi-rality – that is, an identical structure. Only these matches are willing to join together to form pairs and chains. "This is how nature uses information that is inherent in the shape of the molecule to build complex structures," says Magali Lingenfelder.

A molecular encounter: Scanning tunneling microscopy images show how dippeptide molecules dock with each other.
**Anthropology**

**How Long Does a Child Remain a Child?**

Childhood lasted just as long 160,000 years ago as it does today. This has been established by an international team of researchers from the Max Planck Institute for Evolutionary Anthropology and the European Synchrotron Radiation Facility in France. The scientists found that the teeth of a fossilized Homo sapiens child were not any further developed than those of a modern child of the same age; early Homo sapiens experienced a long period of growth and development like our own. However, childhood in Australopithecus and early Homo sapiens lasted hardly longer than that of chimpanzees, which are mature at 10 to 12 years. (PNAS, April 10, 2007)

In purely biological terms, a long childhood has a high price: children cannot feed themselves, they are not prepared for the dangers in their sur-roundings and they cannot reproduce. “However, children have social behaviors more easily when they are cared for and taught by adults,” says Dr. Tanya Smith, who led the project at the Max Planck Institute for Evolutionary Anthropology. Since modern humans must learn more complex social behaviors than other beings, their childhood lasts longer than that of all other primates. The lengthy period of youth also means that teeth and brains grow more slowly. And this was already the case shortly after our species developed from its evolutionary ancestors. This was shown by the international team of researchers using the growth profile of a human who lived 160,000 years ago in Morocco, where the fossil locality Djebel Irhoud is today. Scientists have used the fossilized remains of his teeth to establish that the child was almost eight years of age, and no further developed than a child of the same age in our time. This is by no means self-evident: Homo sapiens’ predecessors, Homo heidelbergensis and Homo erectus, and the earlier Australopithecus species were much more mature at eight years of age. Their youth is believed to have lasted only slightly longer than that of chimpanzees.

“Our results imply that Homo sapiens had the cultural and biological characteristics of today’s humans very early on in their developmental his- tory,” says Smith. “However, if we look at the development of hominids as a whole, these char-acteristics appear only very late in the record — namely in early Homo sapiens.”

The scientists deduced the biological age of the fossil from Djebel Irhoud from its teeth. The tooth enamel is marked by thin growth lines like the annual rings of a tree trunk, which allowed the scientists to reconstruct the timing of tooth growth and the age at which the incisors pushed through from the jaw. This age provides an orien-tation point from which it can be estab-lished how quickly a human grew — even millions of years after his or her death.

However, it is possible to find out pre-cisely how long a tooth had been grow- ing only from the inside of the enamel, since that is the only place where the microscopic daily growth lines can be seen. It is not easy to look at this area without destroying the enamel, but it is now possible thanks to Dr. Paul Taf- foreau, a scientist at the European Syn- chrotron Radiation Facility in Grenoble, who developed a method using micro-tomo-graphy. Tafforeau uses synchrotron X-rays to create three-dimensional im- ages of the very fine structures of the enamel without damaging it. The re-search team compared the structure of the Moroccan child’s 160,000-year-old enamel with that of modern children and other fossil species. “Traditionally, fossils have revealed how humans were constructed anatomically,” she says. “Now, using the record of daily tooth growth, they have allowed us to read the history of a human.”

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**Astrophysics**

**Light Puts Asteroids in a Spin**

Rays from the Sun have never been seen to start a stone rolling on Earth. In space, how- ever, things are a bit different: there, astron-omers from Europe and the US, including Hermann Boenhardt from the Max Planck Institute for Solar System Research, have now shown that light from the Sun exerts a force on 2000 PH5, a small asteroid not far from the Earth. This is, although very weak, is sufficiently to make the asteroid rotate one millisecond faster each year. They have mea-sured the Yarkovsky-O’Keefe-Radzievskii-Paddac effect (YORP for short), which has been theoretically predicted by astrophysi-cists for some time already. (Science Express, March 8, 2007)

Small asteroids generally bear very little similarity to a sphere. Asteroid 2000 PH5, for example, races around space in the form of a flat piece of rock, approximately 120 meters square and slightly less than 60 meters high. Furthermore, bulges distort it so much that of all other primates. The length- ing period of youth also means that teeth and brains grow more slowly. And this was already the case shortly after our species developed from its evolutionary ancestors. This was shown by the international team of researchers using the growth profile of a human who lived 160,000 years ago in Morocco, where the fossil locality Djebel Irhoud is today. Scientists have used the fossilized remains of his teeth to establish that the child was almost eight years of age, and no further developed than a child of the same age in our time. This is by no means self-evident: Homo sapiens’ predecessors, Homo heidelbergensis and Homo erectus, and the earlier Australopithecus species were much more mature at eight years of age. Their youth is believed to have lasted only slightly longer than that of chimpanzees.

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According to this theory, 2000 PH5 rotates a thousandth of a second faster every year, which could eventually make it the fastest-rotating as- teroid in the solar system. If the spin continues to increase at this rate, in 35 million years, 2000 PH5 will take just 20 seconds to spin once around its axis.

But rather than setting a record, this acceler-a-tion could result in a premature end for 2000 PH5 — when its momentum causes it to fly apart. “The YORP effect may make a number of asteroids ro-tate so fast that they break up,” says Hermann Boenhardt. This could also be the reason why as-tronomers have yet to find an asteroid that takes fewer than 80 seconds for one rotation.

Keeping an eye on the asteroid 2000 PH5, photo-graphed with the 3.5-meter telescope at Calar Alto in Spain. The researchers use the fluctuations in its brightness to calculate its rotational speed, which is increasing steadily under the influence of the Sun’s radiation.

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**Notes**

Photos: PNAS, Proceedings of the National Academy of Sciences, USA

Image: Max Planck Research, Katlenburg-Lindau

[Image 107x63 to 327x361]

[Image 479x157 to 502x180]

[Image 595x363 to 1164x503]
The oceans absorb almost a third of the carbon dioxide that humans pump into the atmosphere. This would imply that the amount of carbon dissolved in the sea should rise in tandem with the increasing amount of greenhouse gas in the air. However, this is not the case. The Southern Ocean, for one, has been exhibiting a saturation effect over the last 25 years. This effect has been measured for the first time by an international team of researchers working under the leadership of the Max Planck Institute for Biogeochemistry in Jena. Although carbon dioxide emissions have risen by 40 percent since the early 1980s, the Southern Ocean has not absorbed more carbon dioxide. The blame lies with a feedback effect: climate change, which is causing at least in part by greenhouse gases, is affecting the carbon cycle of the oceans. (Scriege, May 17, 2007)

Geochemists call forest fires, smoking chimneys and also some regions of the world’s seas carbon sources. However, if a forest or an ocean absorbs more carbon dioxide than it gives off, they refer to a carbon sink. The more carbon dioxide the atmosphere contains, the more it should push into the sea. This is how the Southern Ocean changed from being a source to becoming a sink. Just a few decades ago, it was releasing carbon dioxide; now it has become a net absorber of carbon dioxide, since the concentration in the atmosphere has grown so drastically. This is a chemical balance issue and, in principle, also observed in a soda maker.

If the Southern Ocean were to continue to uphold this principle, it could lessen the growing change in the climate. “However, climate change is making the seas absorb less carbon dioxide,” says Professor Martin Heimann, Director at the Max Planck Institute for Biogeochemistry in Jena. “This means that more anthropogenic carbon dioxide will remain in the atmosphere, which in turn will fuel climate change.”

The international team of scientists, which includes researchers from the University of East Anglia and the British Antarctic Survey, now has analyzed observations to confirm this positive feedback effect. For this, it was predicted on theoretical grounds only. The scientists from the Max Planck Institute in Jena have evaluated observations from 42 stations located throughout the world. The stations record the concentrations of greenhouse gases in their surroundings, and some of them have been doing so since the early 1980s. The intensity of the increase or decrease in concentration between the individual stations depends, among other things, on the flow of air, as well as on how much gas the sinks extract from the air. Working backwards from their measurements, the scientists were able to calculate how much carbon dioxide the Southern Ocean is absorbing, and how much its capacity has changed over the last 25 years. The Southern Ocean should actually be absorbing more greenhouse gas today than when the observations began; after all, the concentration of carbon dioxide in the atmosphere has increased significantly. Instead, absorption has stagnated during the last 25 years, as revealed by the observations analyzed by the team of scientists. The blame lies with climate change, which fans the winds over the Southern Ocean. These, in turn, alter the ocean currents, bringing to the surface water that is already saturated with carbon dioxide. Similar phenomena can be observed in other locations. “We have to assume that feedback mechanisms of this kind are increasing climate change in other parts of the world, as well,” says Heimann.