



From left: Adrian Briggs, Johannes Krause, Svante Pääbo and Richard E. Green decoded the Neanderthal genome.

The Genetic Secrets of Old Bones

He is our closest relative, and became extinct about 30,000 years ago: Neanderthal man. For more than a century, paleontologists and anthropologists have been trying to clarify the evolutionary relationship between Neanderthals and modern humans.

Back in July 2006, Svante Pääbo, Director at the Max Planck Institute for Evolutionary Anthropology, began an ambitious project to sequence the entire Neanderthal genome. Two and a half years later – exactly on Darwin’s 200th birthday on February 12, 2009 – Pääbo and his colleagues presented a first draft of the Neanderthal genome to the public. Using specially developed methods, the scientists actually succeeded in sequencing more than a billion DNA fragments. And it took them less than half a gram of fossil bone to do so. In total, the fragments represent more than 60 percent of the genome.

“These sequences can now be compared with the genomes of humans and chimpanzees that have already been sequenced, so we can tell how the genome of the extinct Neanderthals varies from that of modern man,” explained molecular biologist Prof. Pääbo. The researchers hope to find an answer to one of the most exciting questions in human history: Just what genetic changes prompted the development of modern man and caused our species to spread out from Africa across the entire world some 100,000 years ago?

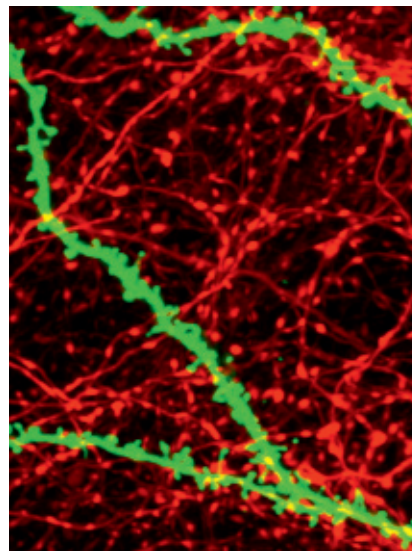
Learning and Forgetting

Experience shows that relearning is usually easier than learning something for the first time. Scientists at the Max Planck Institute for Neurobiology have shown that this subtle difference originates in the wiring in the brain. They looked at the nerve cells that process visual information in mice. If these cells stop receiving signals from the eye to which they are connected, they form new links and process information from the other eye. If the inactive eye starts to function again, the new links are not disconnected – only the synapses are deactivated. This allows the cells to adapt to changes should the eye become inactive again: the original contacts are then simply reactivated. As an experience that has been used once might be used again, the brain seems to keep extensions “in stock.”

(NATURE, November 12, 2008)

Researchers in the same department were able to observe the synapses being broken down in time-lapse imaging with a high-resolution two-photon microscope. To do this, they marked the transmitter nerve cells with a red fluorescent dye and marked the receptor cells with which they were connected with a green fluorescent dye. These experiments showed that not only the receiving part (the spine), but also the transmitting part (the bouton) of the synapse was actively broken down when the contact point was no longer needed. Using the microscope, the scientists witnessed for the first time the “separation” of the link between the bouton and the spine, showing that the breakdown of the spine does indeed result in the loss of the synapse.

(NEURON, November 26, 2008)



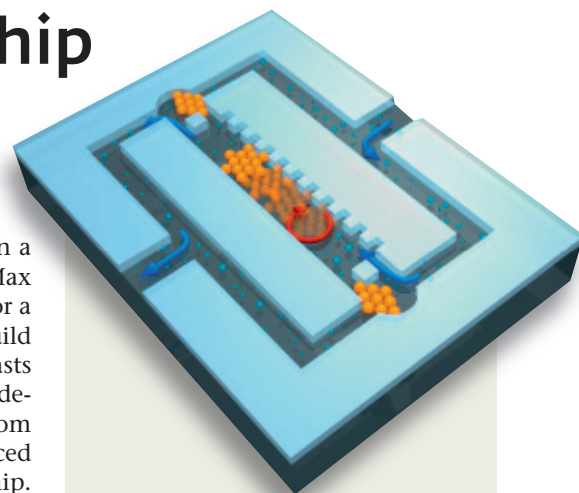
Nerve cells in the brain communicate effectively only when the tiny nodular transmitters (red) and the corresponding receivers (green) come together in the correct proportions.

The Ship-in-a-Bottle Microchip

Remote controlled with a magnetic field, aggregates composed of plastic particles on a microchip act as stirrers or pumps.

It would be cheaper to analyze blood samples or DNA on a microchip than in a traditional laboratory. A team of researchers that included scientists from the Max Planck Institute for Metals Research constructed valves, a pump and a stirrer for a laboratory on a microchip. To do this, they used a trick similar to that used to build a ship in a bottle. In the same way that model makers postpone erecting the masts and the rigging until the vessel is in the bottle, the scientists do not put the devices together until they are in the tiny appliance. Working with researchers from the University of Stuttgart and the Colorado School of Mines, they introduced magnetizable colloid particles – tiny plastic spheres – into the spaces on the chip. Then they used a magnetic field to construct diamond shapes or cog wheels from the particles and start them moving. In order to force the spheres to come together into the machine component the scientists want to create, the geometry of the spaces must be chosen very carefully.

Analysis on microchips requires only very small samples, which would reduce costs. Furthermore, it would be possible for doctors to carry out investigations at the scene of an accident, because devices with this microtechnology could easily be accommodated on board emergency vehicles. (PNAS, December 5, 2008)



Pumps team up and work together:

In a magnetic field, the microspheres (orange) form diamond-shaped valves and a cog wheel. With skillful manipulation of a magnetic field, the wheel rolls through the cavity and coacts with the valves to create a pump.

A Silent Gene Fattens Flies

To find out the function of a gene, or rather of the protein that it produces, biologists switch it off. This is how researchers at the Max Planck Institute for Biophysical Chemistry and the National Institutes of Health in Bethesda, USA discovered a protein complex in the fruit fly, *Drosophila*, that plays a key role in regulating the metabolism of fat. This complex, which is made up of at least seven sub-units, appears to act on the surface of fat-storing lipid droplets, where it controls a kind of gate function with other proteins. If the complex is missing because the gene has been switched off, the flies do not break down the fat in the lipid droplet. Because the same protein complex also exists in mice and clearly has a similar effect, it is hoped that it will also be shown to exist in human cells, thus providing a new approach for the treatment of obesity.

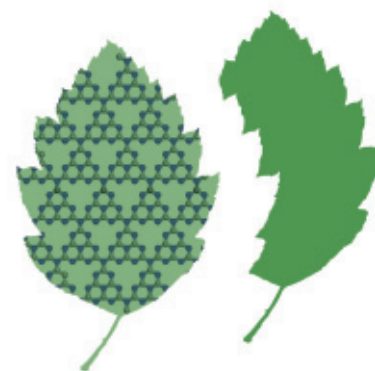
(PLOS BIOLOGY, November 25, 2008)

A Water-Splitter in a Double Role

While great hopes are pinned on hydrogen, it also presents some problems. It is energy-rich, clean and, in the form of water, of almost unlimited supply. To date, however, it has proved difficult to extract it.

Scientists at the Max Planck Institute of Colloids and Interfaces have now found a simple, low-cost way to produce hydrogen. They irradiate water with sunlight and use one of the oldest artificial polymers as a cheap photocatalyst – a very stable carbon nitride that was first manufactured by Justus Liebig as early as 1834. Previously, inorganic semiconductors and expensive precious metals such as platinum were required to produce hydrogen from water using light. The semiconductor acts as an antenna for the light, and the precious metal as a catalyst.

The carbon nitride now performs both functions at the same time, proving that the process works in principle with an organic catalyst – although up to now, this has been significantly less efficient than the traditional method. In a slightly altered experiment, the carbon nitride also extracts hydrogen from water when it is irradiated with sunlight. The Max Planck researchers are now trying to combine the two reactions, imitating photosynthesis in plants. (NATURE MATERIALS, January 2009)



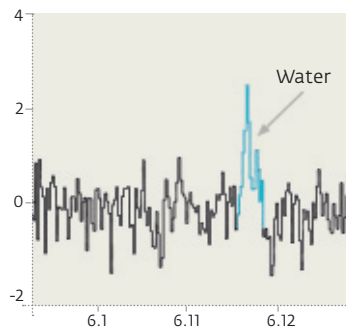
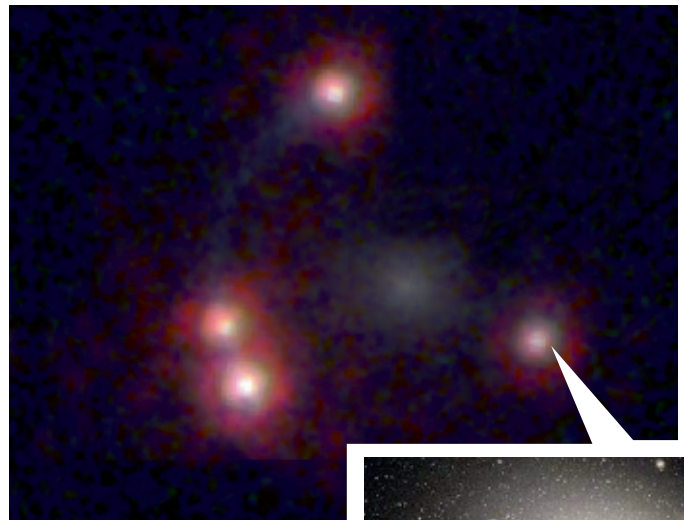
Plants use the energy in sunlight to synthesize sugar. Max Planck researchers hope to copy this process using the net-like structure of carbon nitride.

At the Source of the Universe

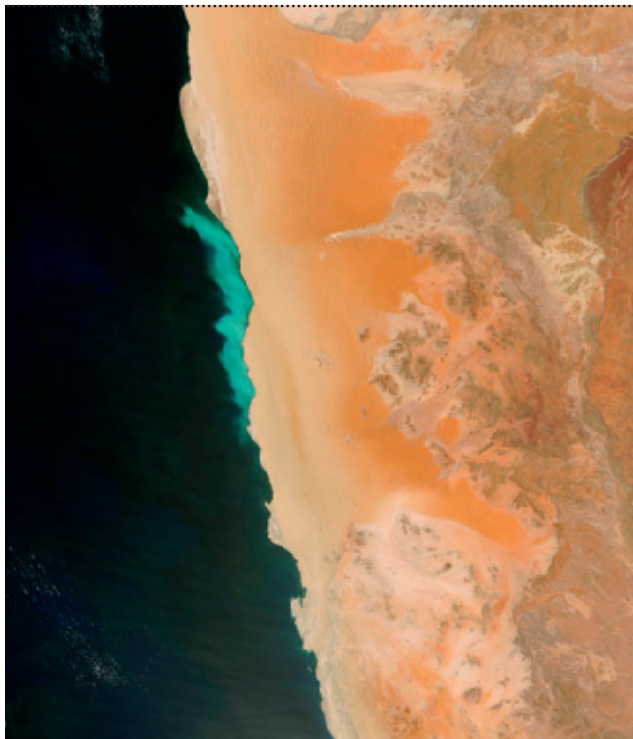
An international team of researchers discovered water at a distance of more than 11 billion light years. This means that there was already enough water in the universe when it was just 2.5 billion years old to be evident today. It also means that stars were already producing oxygen in abundance at that time. The team, which included several researchers from the Max Planck Institute for Radio Astronomy, found the water in a quasar, a black hole at the center of a swirling disk of gas and dust.

The success of this discovery was brought about by a very ingenious piece of astronomical observation. From the vantage point of the Earth, the quasar is hidden by a galaxy. However, far from making the observations more difficult for the researchers, it was this galaxy that enabled them to see the quasar, as it acted as a gravitational lens and made the light of the quasar significantly brighter. Without this effect, the astronomers would have had to collect light for 580 days to show that the water existed. As it was, 14 hours were sufficient, but only because the light characteristic for water molecules originated from a maser. This acts like an optical laser in the microwave range and radiates a particularly intense and bundled light. Finding a maser of this kind in the early universe was another surprise for the scientists.

(NATURE, December 18, 2008)



Max Planck researchers used the radio telescope in Effelsberg to show that there is water in a quasar called MG J0414+0534. A galaxy in the foreground split the light into four parts and amplified it.



Bacteria Detoxify Seawater

In the over-fertilized coastal regions of the oceans, certain sea-living bacteria can produce hydrogen sulfide – a compound that not only smells unpleasantly of rotten eggs, but is also extremely toxic. Even at relatively low concentrations, it can cause higher organisms to stop breathing, and inflict considerable damage on coastal fisheries by killing fish, crabs and lobsters.

An international team of researchers including scientists from the Max Planck Institute for Marine Microbiology in Bremen discovered adversaries of the bacteria that produce this deadly hydrogen sulfide. The adversaries are also bacteria, so-called nitrate respirers, which fuel their energy metabolism with nitrate rather than oxygen. Using this nitrate, the bacteria process the hydrogen sulfide as “food” and convert it to harmless elemental sulfur.

(NATURE, January 29, 2009)

A satellite image showing the toxic slick: Bacteria convert toxic hydrogen sulfide to harmless sulfur, which colors the sea turquoise.

Proteins Instead of Antibiotics

Some viruses render bacteria harmless with special proteins, thus offering an alternative to antibiotics that have become ineffective. Max Planck scientists have used a genetically modified tobacco plant to produce large quantities of a protein of this nature.

Pathogens also attack each other: certain viruses, called bacteriophages, force their way into bacteria, where they reproduce and then dissolve the cell walls. The proteins they use to break through the bacteria walls are called lysines and could be used as a way to combat pathogenic bacteria in the future, because many bacteria have since become resistant to traditional antibiotics.

Scientists working with Ralph Bock, Director at the Max Planck Institute for Molecular Plant Physiology in Potsdam, have genetically programmed tobacco plants to produce a special form of lysine. The protein targets some strains of the *Streptococcus* genus of bacteria that can cause a number of serious illnesses. "Tests on bacterial cultures have shown that lysine is very effective," says Melanie Oey, who played a major role in the studies. Attempts to use bacteriophages against

bacteria date back to as early as the beginning of the last century. Manufacturing an antibacterial virus protein in plants, however, is a new and promising approach, not least because it is a low-cost production method.

The researchers spliced the genetic construction manual for the proteins into the chloroplasts in which photosynthesis takes place. These cell organelles are particularly suitable production sites for proteins, as they possess their own genetic information and they occur in large numbers in the plant cells. The genetic information is translated much more frequently there than in the cell nucleus, of which there is only one per cell. This might be one reason why the lysine makes up as much as 70 percent of the total plant protein according to the experiments. However, the fact that the plant's enzymes hardly break down the protein is presumably also a contributing factor.



Bioreactor:
Tobacco plants
are well suited
for producing
proteins.

Using chloroplasts for antibiotic production could also prevent the genes from distributing themselves in an uncontrolled manner, because their genetic information is not contained in the pollen. The biologists in Potsdam used a sophisticated method to insert the genes into the chloroplasts. They attached the genes to microscopically small gold spheres and used a cannon to shoot the loaded spheres into the chloroplasts. (PLANT JOURNAL; online on October 27, 2008)



"You're a bit on the puny side" – when this is how the female (right) sees the male, she lays extra large eggs.

The Trouble with Puny Males

Usually, the energy that female birds expend on attempting to raise a brood is directly proportional to the attractiveness of their partners, because this promises that the offspring will also be presentable representatives of the species.

Researchers at the Max Planck Institute for Ornithology in Seewiesen found out that this is not the case with zebra finch females. If they are partnered with a less attractive male, they make a greater effort, laying "extra large" eggs that contain more nutrients. This behavior is explained by the monogamous lifestyle of the zebra finch female. As a pair generally mates for life, it is not worthwhile for the female to be miserly with its resources.

It is in the interest of the offspring if she compensates for the deficits of the "puny" partner as much as she can, and invests as much start-up capital as possible in the eggs.

(PROCEEDINGS, November 5, 2008)



Food as far as the eye can see – but it's not always the right kind: When female gorillas, like this one in Bwindi National Park in Uganda, look for a new family, they take the food supply in their new habitat into account.

Just Like Mom Used to Make

Female mountain gorillas prefer to join new families that live in areas with a food supply similar to that in the region where they originated.

When female gorillas set out to reproduce in a new group, they are choosier than previously thought. They prefer to join groups that inhabit similar vegetation zones to that of their own family, because then they know which plants they and their offspring will find most satisfying. A team of researchers from the Max Planck Institute for Evolutionary Anthropology conducting genetic studies on a gorilla population in Bwindi National Park in Uganda found that unfamiliarity with the vegetation could mean that the gorillas reproduce less successfully.

Up to now, primate researchers assumed that the available food supplies do not play an important role in the female's choice of a new family because the abundant vegetation in the mountain gorillas' habitat offers sufficient nourishment wherever they are.

However, it appears that female gorillas do not always rely on this being the case. In contrast, the Max Planck researchers found that male gorillas cannot afford to choose their habitat on the basis of familiar green stuff. As they are under more pressure to compete, they are happy just to find a partner, whatever the nature of the food.

Gorillas are one of the few mammals where the females leave their family to join a new one. As the females bear the high costs of reproduction – feeding babies and raising the offspring – they usually remain on familiar terrain, where they know what food is available and where the safe places are. Furthermore, their family is close by to help in emergencies.

(CURRENT BIOLOGY, November 25, 2008)

Photo: MPI for Evolutionary Anthropology – Katerina Guschanski

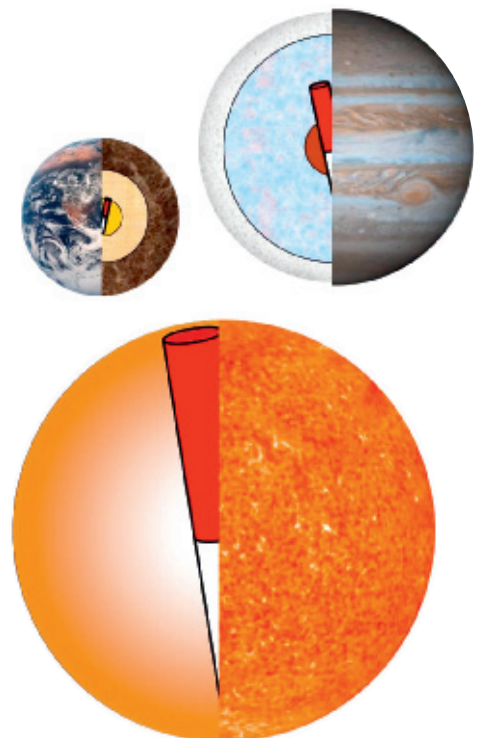
Radiation Determines Strength of Cosmic Magnets

Jupiter is surrounded by a magnetic field ten times stronger than that of the Earth, and the magnetic field of some stars is even a thousand times more powerful still. Scientists from the Max Planck Institute for Solar System Research have now found an explanation for these differences. They developed a theory that can be applied to both planets and stars, provided that they – like the Earth, Jupiter and most stars with much less mass than the Sun – rotate quickly.

According to this theory, the strength of the magnetic field depends mainly on the energy a heavenly body emits in the form of light or heat. Some of this is available in its interior and generates electrical currents and thus the magnetic field. Up to now, scientists believed that the strength of the mag-

netic field depended only on the speed at which the heavenly body was rotating: functioning like a dynamo, the movement of the ionized material in its interior creates a magnetic field. Up to a certain rotation period, which might be one or a few days, depending on the heavenly body in question, the strength of the magnetic field does, indeed, increase with the speed of rotation. With the new model, it is possible to form predictions about the magnetic fields of planets and stars that astrophysicists have as yet been unable to quantify. (NATURE, January 8, 2009)

Magnets in space: Rapidly rotating stars, Jupiter and the Earth all create magnetic fields similar to that of a bar magnet. The fields, however, vary greatly in strength.



Graphic: MPI for Solar System Research – U. Christensen

The Dance around a Black Hole

Since 1992, scientists at the Max Planck Institute for Extraterrestrial Physics in Garching have been tracking the movements of 28 stars in the central area of the Milky Way. These long-term observations confirm the conjecture that there is a supermassive black hole at the heart of the galaxy, and they also supply the first accurate data about it. According to this data, the black hole holds around four million closely packed solar masses, and our solar system is 27,000 light-years from this “nucleus” of the Milky Way.

In the study, the positions, and thus also the movement, of the 28 stars were each measured accurately to three ten-thousandths of an arc second – an angle at which a one-euro coin would appear at a distance of approximately 10,000 kilometers. The stars were thus used as “test particles,” and their orbits allowed conclusions to be drawn about the forces in the more immediate environment of the galactic center.

It was revealed that the innermost region around the center – within a radius of approximately one light-month – is extremely turbulent, with stars moving completely randomly, like a swarm of bees. It is only further out that 6 of



At the center of the Milky Way: The image from the Very Large Telescope in Chile shows hot blue and cooler red stars, as well as glowing red gas clouds.

the 28 stars orbit the black hole in one plane. And since the observations began, one of the stars completed a full orbit around the galactic center.

(THE ASTROPHYSICAL JOURNAL 692 [2009] 1075-1109)

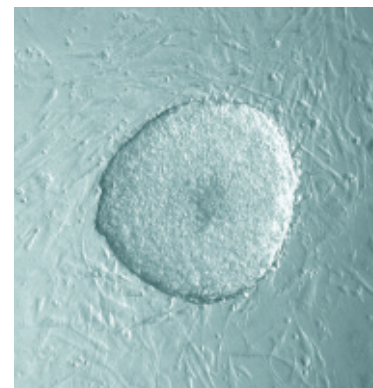
Declining Birth Rates – When Later Often Means Never

Not one European country can match the average birth rate of 2.1 that would be necessary for the present generation of children to replace their parents one for one. This was revealed by a study headed by the Max Planck Institute for Demographic Research in Rostock. In the Scandinavian countries, Ireland and France, the birth rate is between 1.8 and 2.0. At the other end of the scale, some of the former Eastern Bloc countries, such as Poland and the Czech Republic, are worst off, with rates below 1.2. And in Germany and the countries of southern Europe, birth rates are only about a tenth of a percent higher.

The researchers believe that one reason for our over-aging continent is that many couples initially put off having children, and then have fewer offspring in their late thirties or early forties, or even none at all. As for why couples get around to having children so late in life, the researchers in Rostock put this down to an increased interest in good education and training and increasingly higher rates of female employment.

The Deciding Factor

“Waiting for a Miracle” was the title of an article published in 2005 in MAXPLANCKRESEARCH about an international meeting of stem cell researchers. “Some estimate ‘around three,’ others ‘seven to ten’ or ‘perhaps even twenty.’ The issue here is the number of proteins in a magic cocktail that would convert mature body cells to embryonic stem cells,” the article continues. Today, four years later, the researchers know that only one factor is required. The team working with Hans Schöler from the Max Planck Institute for Molecular Biomedicine in Münster succeeded in reprogramming the adult nerve cells in a mouse with a single gene. It is the transcription factor Oct4. That precisely Oct4 is the factor – among the many others tested – that is sufficient for a new start is a déjà vu experience for Schöler, as he discovered this factor in the egg cells of mice in the late 1980s, and described the relevant gene shortly afterward. (CELL, Advance Publications, February 6, 2009)



It is as easy to develop heart, nerve or germ cells from single-factor iPS as it is from iPS that have been reprogrammed with four factors.