Innovations Report

Feb 2006 Part II

- ICT
- Microelectr. & Nanotech
- Life Sciences

Table of Contents

ICT

Quantum computer works best switched off

Even for the crazy world of quantum mechanics, this one is twisted. A quantum computer program has produced an answer without actually running.

The idea behind the feat, first proposed in 1998, is to put a quantum computer into a “superposition”, a state in which it is both running and not running. It is as if you asked Schrödinger's cat to hit "Run".

With the right set-up, the theory suggested, the computer would sometimes get an answer out of the computer even though the program did not run. And now researchers from the University of Illinois at Urbana-Champaign have improved on the original design and built a non-running quantum computer that really works.

They send a photon into a system of mirrors and other optical devices, which included a set of components that run a simple database search by changing the properties of the photon.

The new design includes a quantum trick called the Zeno effect. Repeated measurements stop the photon from entering the actual program, but allow its quantum nature to flirt with the program's components - so it can become gradually altered even though it never actually passes through.

"It is very bizarre that you know your computer has not run but you also know what the answer is," says team member Onur Hosten.

This scheme could have an advantage over straightforward quantum computing. "A non-running computer produces fewer errors," says Hosten. That sentiment should have technophobes nodding enthusiastically.

Journal reference: *Nature* (vol 439, p 949)

Nanoscience Study Shows That Quantum Dots "Talk"

Scientists who hope to use quantum dots as the building blocks for the next generation of computers have found a way to make these artificial atoms communicate.

“Essentially, the dots talk to each other,” said Ameenah Al-Ahmadi, an Ohio University doctoral student who published the findings with Professor of Physics Sergio Ulloa in a recent issue of the journal Applied Physics Letters.

The dots are tiny, engineered spherical crystals about 5 nanometers in diameter. An average biological cell, in comparison, has a diameter of about 1,000 nanometers. Researchers believe that quantum dots will be extremely useful in developing nanoscale technologies because they are versatile and uniform, which could eliminate possible variations and flaws in materials.

In the recent study, the researchers were the first to use theoretical models to show how light energy shining on quantum dots would prompt them to transfer energy in a “coherent” fashion. They found that when the dots were arranged a certain distance from each other – greater than the radius of the dots – light waves traveled between the nanocrystals in a consistent pattern. In previous research, the light’s wavelength would change or become irregular during the energy exchange, which creates a breakdown in communication between quantum dots.

The results suggest that there could be a way to transmit information using light waves, laying the groundwork for a possible optical quantum computer. In this device, light energy would replace the electrical charge currently used to transfer information in conventional computers.

“The idea is to make the (computing) process faster and smaller,” said Al-Ahmadi.

The applications of the new quantum dot technology also could include medical imaging. Quantum dots could be injected into the patient, and a device containing more quantum dots could be used to show the position of dots under the skin. Current biology research has had great success with this type of imaging in mouse models, Ulloa said. The dots have fewer side effects than contrast chemicals used in X-rays, and may eventually replace traditional contrast media.

Using light energy instead of electricity also would help keep computer temperatures low, as the light energy does not create as much heat as electrical current, Al-Ahmadi added.

Faster than Fiber

A new wireless technology could beat fiber optics for speed in some applications.

Atop each of the Trump towers in New York City, there's a new type of wireless transmitter and receiver that can send and receive data at rates of more than one gigabit per second -- fast enough to stream 90 minutes of video from one tower to the next, more than one mile apart, in less than six seconds. By comparison, the same video sent over a DSL or cable Internet connection would take almost an hour to download.

This system is dubbed "**WiFiber**" by its creator, **GigaBeam**, a Virginia-based telecommunications startup. Although the technology is wireless, the company's approach -- high-speed data transferring across a point-to-point network -- is more of an alternative to fiber optics, than to Wi-Fi or Wi-Max, says John Krzywicki, the company's vice president of marketing. And it's best suited for highly specific data delivery situations.

This kind of point-to-point wireless technology could be used in situations where digging fiber-optic trenches would disrupt an environment, their cost be prohibitive, or the installation process take too long, as in extending communications networks in cities, on battlefields, or after a disaster.

Blasting beams of data through free space is not a new idea. LightPointe and Proxim Wireless also provide such services. What makes GigaBeam's technology different is that it exploits a different part of the electromagnetic spectrum. Their systems use a region of the spectrum near visible light, at terahertz frequencies. Because of this, weather conditions in which visibility is limited, such as fog or light rain, can hamper data transmission.

GigaBeam, however, transmits at 71-76, 81-86, and 92-95 gigahertz frequencies, where these conditions generally do not cause problems. Additionally, by using this region of the spectrum, GigaBeam can outpace traditional wireless data delivery used for most wireless networks.

Because so many devices, from Wi-Fi base stations to baby monitors, use the frequencies of 2.4 and 5 gigahertz, those spectrum bands are crowded, and therefore require complex algorithms to sort and route traffic -- both data-consuming endeavors, says Jonathan Wells, GigaBeam's director of product development. With less traffic in the region between 70 to 95 gigahertz, GigaBeam can spend less time routing data, and more time delivering it. And because of the directional nature of the beam, problems of interference, which plague more spread-out signals at the traditional frequencies, are not likely; because the tight beams of data will rarely, if ever, cross each other's paths, data transmission can flow without interference, Wells says

Until a few years ago, the use of these electromagnetic frequencies that have enabled Gigabeam to build a higher-speed network, were off-limits for two reasons. First, the Federal Communication Commission (FCC) approved public use of these high frequencies only in 2003, says Wells. When the FCC finalized the agreement in 2005, GigaBeam began to ship prototypes.

Second, there was no cost-effective material for making transmitters at such frequencies. Wireless transmitters that send traditional signals are made of silicon, which can't operate at frequencies in GigaBeam's range. Within the past few years, Wells says, manufacturing techniques for making high-frequency radio transmitters out of gallium arsenide have improved significantly, making the technology less cost prohibitive.

While working at these frequencies permits high-speed data rates, there's an intrinsic physical challenge: molecules in the atmosphere absorb energy at certain frequencies. To deal with this, GigaBeam exploits those frequencies that are less susceptible to absorption by air and water molecules.
But the technology is still susceptible to heavy rains. In arid conditions, Gigabeam's signal can travel about 10 miles, but in areas where heavy rains occur, says Wells, the company's radios are only guaranteed to push a signal for about a mile, with the transmission will be down for a maximum of only five minutes per year.

Even with its advances, though, Gigabeam faces the same problem as other point-to-point technologies: creating a network with an unbroken sight line. Still, it could offer some businesses an alternative to fiber optics. Currently, a GigaBeam link, which consists of a set of transmitting and receiving radios, cost around $30,000. But Krzywicki says that improving technology is driving down costs. In addition to outfitting the Trump towers, the company has deployed a link on the campuses of Dartmouth College and Boston University, and two links for San Francisco's Public Utility Commission.

Hackers beware! New technique uses photons, physics to foil codebreakers

Quantum cryptography allows transmission of data through fibre optic cables

For governments and corporations in the business of transmitting sensitive data such as banking records or personal information over fibre optic cables, a new system demonstrated by University of Toronto researchers offers the protective equivalent of a firebreathing dragon.

Quantum cryptography is trying to make all transmissions secure, so this could be very useful for online banking, for example," says Professor Hoi-Kwong Lo, an expert in physics and electrical and computer engineering at U of T's Centre for Quantum Information and Quantum Control and the senior author of a new study about the technique. "The idea can be implemented now, because we actually did the experiment with a commercial device."

The study describes the first experimental proof of a quantum decoy technique to encrypt data over fibre optic cable. In quantum cryptography, laser light particles (photons) carry complex encryption keys through fibre optic cables, dramatically increasing the security of transmitted data. Conventional encryption is based on the assumed complexity of mathematical problems that traditional computers can solve. But quantum cryptography is based on fundamental laws of physics — specifically, Heisenberg's Uncertainty Principle, which tells us that merely observing a quantum object alters it. The technique varies the intensity of photons and introduces photonic "decoys," which were transmitted over a 15-kilometre telecommunication fibre. After the signals are sent, a second broadcast tells the receiving computer which photons carried the signal and which were decoys. If a hacker tries to "eavesdrop" on the data stream to figure out the encryption key, the mere act of eavesdropping changes the decoys — a clear sign to the receiving computer that the data has been tampered with.

The study appears in the Feb. 24 issue of Physical Review Letters

Sheffield Hallam University

Breakthrough in split second 3D face imaging

Face recognition technology that could revolutionise security systems worldwide has been developed by computer scientists at Sheffield Hallam University. The new specialist software can produce an exact 3D image of a face within 40 milliseconds.

Other 3D systems that have been trialled have proved unworkable because of the time it takes to construct a picture and an inaccurate result.

The ground-breaking invention, by experts in the University's Materials and Engineering Research Institute (MERI) was tested by Home Secretary Charles Clarke on a recent visit to Sheffield. It could be used for tighter security in airports, banks, and government buildings and ID cards.

The breakthrough comes days after MPs backed the compromise plans for identity cards, meaning from 2008 people applying for a new passport will also get an identity card, with their biometric details stored on a central register.

The new technology works by projecting a pattern of light onto the face, creating a 2D image, from which 3D data is generated. Biometric features are extracted by a 'parameterisation' process, giving a digital mapping of a face that would form part of a fool-proof security system.

MERI's Professor Marcos Rodrigues said: "This technology could be used anywhere there is a need for heightened security. It is well suited to a range of applications including person identification from national databases, access control to public and private locations, matching 3D poses to 2D photographs in criminal cases, and 3D facial biometric data for smart cards such as ID and bank cards. We have developed a viable, working system at the cutting edge of 3D technology."

Microelectronics & Nanotech

Clearing the Atomic Roadblock

University at Buffalo engineers are working to solve two significant roadblocks impeding the creation of smaller, faster and more powerful electronic devices. Working atom by atom, Cemal Basaran and David Kofke are taking on the problems of electromigration and thermomigration -- the tendency for atoms to behave erratically when charged by the very high density electrical currents required to power very small but super-powerful electronic devices.

Basaran is director of the Electronics Packaging Lab in the UB School of Engineering and Applied Sciences and is professor in its Department of Civil, Structural and Environmental Engineering. A UB Distinguished Professor, Kofke is chair of the Department of Chemical and Biological Engineering in the School of Engineering and Applied Sciences.

High electrical current densities and high temperature gradients create voids within metal conductors, the researchers explain. This leads to breakdowns in circuitry and results in device failure. Moreover, as electronic devices and their circuits get smaller -- down to the nanoscale -- the damaging effects of electromigration and thermomigration increase.

With the support of a $250,000 grant from the US National Science Foundation, Basaran and Kofke are using computer simulations and laboratory experiments to devise ways to lessen or stop electromigration and thermomigration. Engineers from Intel are collaborating with the UB researchers on the project.

"Once we learn to stop this self-destructive process in metals, any component in a computer chip can be made at the nanoscale," says Basaran. "But unless you solve this problem, you cannot have fast - performing nanoelectronic devices, and further miniaturization in electronics may not be possible."

Penn State

Titania nanotubes create potentially efficient solar cells

A solar cell, made of titania nanotubes and natural dye, may be the answer to making solar electricity production cost-effective, according to a Penn State researcher.

"Solar cell technology has not changed very much over time and is still predominantly silicon solar cells," says Dr. Craig Grimes, professor of electrical engineering and materials science and engineering. "It takes a great deal of energy, 5 gigajoules per square meter, to make silicon solar cells. It can be argued that silicon solar cells never fully recover the energy it takes to make them in the first place."

The new focus in solar cells is toward dye sensitive solar cells, which have been made using nanoparticles and a variety of dyes.

"Nanoparticle solar cells are the gold standard of this new approach," says Grimes. "However, because of limitations, it appears they have gotten as good as they are going to get."

The researchers are instead looking at titania nanotubes to replace the particulate coatings in dye sensitive solar cells and, their initial attempt produced about 3 percent conversion of solar energy to electricity, they report in today's issue of Nano Letters. The researcher's inability to grow longer titania nanotubes, constrained the solar conversion rate.

"I think we can reach a 15 percent conversion rate with these cells, and other researchers do as well," says Grimes. "That is 15 percent with a relatively easy fabrication system that is commercially viable."

Conventional solar cells are made from blocks of slowly made silicon boules that are sliced into wafers. Grimes and his team use an easier approach. They coat a piece of glass with a fluorine-doped tin oxide and then sputter on a layer of titanium. The researchers can currently lay down a 500-nanometer thick titanium layer. They then anodize the layer by placing it in an acidic bath with a mild electric current and titanium dioxide nanotube arrays grow to about 360 nanometers. The tubes are then heated in oxygen so that they crystalize. The process turns the opaque coating of titanium into a transparent coating of nanotubes.

This nanotube array is then coated in a commercially available dye. The dye-coated nanotubes make up the negative electrode and a positive electrode seals the cell which contains an iodized electrolyte. When sun shines through the glass, the energy falls on the dye molecules and an electron is freed. If this electron and others make their way out of the tube to the negative electrode, a current flows. Many electrons do not and are recombined, but the tube structure of the titanium dioxide allows an order of magnitude more electrons to make it to the electrode than with particulate coatings.

"There is still a great deal of optimization of the design that needs to be done," says Grimes. "Now, with the help of the Pennsylvania Energy Development Authority, we will have equipment to make high quality titanium coatings that are thicker. If we get about 3 percent conversion with 360 nanometers, what we could get with 4 microns is an exciting question we soon hope to answer."

The thickness of the titanium layer constrains the height of the nanotubes. With thicker initial coatings, longer tubes would produce more electrons that do not recombine, producing more electricity.

Other aspects of the titania nanotube dye sensitive solar cells that need to be optimized include the thickness of the cells. Currently, spacers separate the two layers and provide internal support. These spacers are 25 microns thick. If the spacers could be made as sturdy, but shorter, there would be less of a distance for the electrons to travel and more electrons will make it across the electrodes.

NIST Method May Help Optimize Light-emitting Semiconductors

Physicists at JILA have demonstrated an ultrafast laser technique for "seeing" once-hidden electronic behavior in semiconductors, which eventually could be useful in more predictable design of optoelectronic devices, including semiconductor lasers and white light-emitting diodes.

The work at JILA, a joint institute of the National Institute of Standards and Technology and the University of Colorado at Boulder, is described in the Feb. 10 issue of Physical Review Letters. The technique manipulates light energy and wave patterns to reveal subtle behavior, such as correlated oscillations of two objects. Such correlations are important because they may allow researchers to more accurately predict the emission frequencies produced by an optoelectronic device based on its structure and semiconductor materials.

The method was developed originally by other researchers years ago for probing couplings between spinning nuclei as an indicator of molecular structure, and it led to a Nobel prize; more recently, scientists have been trying to use it to study vibrations in chemical bonds. The JILA team is the first to show the approach offers new insights into electronic properties of semiconductors. The use of light as a precision tool to manage electronic behavior could lead to improved optoelectronic devices.

In the JILA technique, a sample made of thin layers of gallium arsenide is hit with a continuous series of three near-infrared laser pulses lasting just 100 femtoseconds each. Trillions of electronic structures called excitons are formed. They consist of "excited" electrons and the "holes" they leave behind as they jump to higher energy vibration patterns. By changing the timing of the laser pulses and analyzing the wave patterns of the light and exciton oscillations, the JILA scientists figured out how to produce and identify correlations between absorption and emission of light from the material. The presence or absence of correlations can be seen in a computer plot of the frequency and wave pattern of the absorbed and emitted light. Correlations are revealed as a pair of similar butterfly-shaped plots.

New Georgia Tech Probe Revolutionizes Nano Imaging

Georgia Tech researchers have created a highly sensitive atomic force microscopy (AFM) technology capable of high-speed imaging 100 times faster than current AFM. This technology could prove invaluable for many types of nano-research, in particular for measuring microelectronic devices and observing fast biological interactions on the molecular scale, even translating into movies of molecular interactions in real time.

The research, funded by the National Science Foundation and the National Institutes of Health, appears in the February issue of Review of Scientific Instruments.

Not only is FIRAT™ (Force sensing Integrated Readout and Active Tip) much faster than AFM (the current workhorse of nanotech), it can capture other measurements never before possible with AFM, including material property imaging and parallel molecular assays for drug screening and discovery.

FIRAT could also speed up semiconductor metrology and even enable fabrication of smaller devices. It can be added with little effort to existing AFM systems for certain applications.

"I think this technology will eventually replace the current AFM, " said Dr. Levent Degertekin, head of the project and an associate professor at Georgia Tech.

"We've multiplied each of the old capabilities by at least 10, and it has lots of new applications. "

FIRAT solves two of AFM's chief disadvantages as a tool for examining nanostructures — AFM doesn't record movies and it can 't reveal information on the physical characteristics of a surface, said Dr. Calvin Quate, one of the inventors of AFM and a professor at Stanford University.

"It is possible that this device provides us with the 'ubiquitous' tool for examining nanostructures," Quate added.

And what's the key to this dramatic increase in speed and capabilities? A completely new microphoneinspired probe.

Current AFM scans surfaces with a thin cantilever with a sharp tip at the end. An optical beam is bounced off the cantilever tip to measure the deflection of the cantilever as the sharp tip moves over the surface and interacts with the material being analyzed.

FIRAT works a bit like a cross between a pogo stick and a microphone. In one version of the probe, the membrane with a sharp tip moves toward the sample and just before it touches, it is pulled by attractive forces. Much like a microphone diaphragm picks up sound vibrations, the FIRAT membrane starts taking sensory readings well before it touches the sample.

And when the tip hits the surface, the elasticity and stiffness of the surface determines how hard the material pushes back against the tip. So rather than just capturing a topography scan of the sample, FIRAT can pick up a wide variety of other material properties.

For instance, FIRAT can scan integrated circuits for defects or, in biomolecular applications, can scan a surface quickly enough for a researcher to observe molecular interactions in real time.

"The potential is huge. AFM started as a topography tool and has exploded to many more uses since. I'm sure

Life Sciences

Washington University School of Medicine

Oncologists Could Gain Therapeutic Advantage By Targeting Telomere Protein

Inactivating a protein called mammalian Rad9 could make cancer cells easier to kill with ionizing radiation, according to research at Washington University School of Medicine in St. Louis.

The researchers found that Rad9, previously considered a "watchman" that checks for DNA damage, is actually a "repairman" that fixes dangerous breaks in the DNA double helix. They found Rad9 is especially active in telomeres, the protective ends of chromosomes.
Because of this new role, Rad9 has gained the researchers' interest as a potential target for cancer therapy -- knocking out Rad9 would enhance the power of radiation treatments by making it easier for radiation to inflict fatal damage to a tumor's genetic material. Their study appears in the March issue of the journal Molecular and Cellular Biology, which is now available online.

"Our study suggests that if we could inactivate Rad9 in tumor cells, we would be able to kill them with a very low dose of radiation and gain a therapeutic advantage," says senior author Tej K. Pandita, Ph.D., associate professor of radiation oncology and on the faculty of the Siteman Cancer Center at Washington University School of Medicine and Barnes-Jewish Hospital.

The study revealed that Rad9 proteins interact with chromosomes' telomeres, which are special structures at the ends of chromosomes that protect them from fusion or degradation. Specifically, Rad9 proteins were shown to interact with proteins called telomere binding proteins. When the scientists inactivated Rad9 in human cells, they saw damage to chromosomes and end-to-end fusion at telomeres. DNA damage and chromosomal fusion can disrupt the cell cycle and cause cell death. Because radiation treatments increase these incidents, loss of Rad9 in cancer cells could enhance the killing effect of radiation.

UCLA scientists find male gene in brain area targeted by Parkinson's
Discovery may explain why more men than women develop the disease

UCLA scientists have discovered that a sex gene responsible for making embryos male and forming the testes is also produced by the brain region targeted by Parkinson's disease. Published in the Feb. 21 edition of Current Biology, the new research may explain why more men than women develop the degenerative disorder, which afflicts roughly 1 million Americans.

"Men are 1.5 times more likely to develop Parkinson's disease than women," said Dr. Eric Vilain, associate professor of human genetics at UCLA. "Our findings may offer new clues to how the disorder affects men and women differently, and shed light on why men are more susceptible to the disease."

In 1990, British researchers identified SRY as the gene that determines gender and makes embryos male. Located on the male sex chromosome, SRY manufactures a protein that is secreted by cells in the testes. Now, in an unexpected discovery, Vilain's team became the first to trace the SRY protein to a region of the brain called the substantia nigra, which deteriorates in Parkinson's disease.

Parkinson's disease occurs when cells in the substantia nigra begin to malfunction and die. These brain cells produce a neurotransmitter called dopamine that communicates with the brain areas controlling movement and coordination. As the cells die off, they produce less dopamine. This slows the delivery of messages from the brain to the rest of the body, leaving the person unable to initiate or control their physical movements. The condition eventually leads to paralysis.

"For the first time, we've discovered that the brain cells that produce dopamine depend upon a sex-specific gene to function properly," Vilain said. "We've also shown that SRY plays a central role not just in the male genitals, but also in regulating the brain."

Vilain's lab used a rat model to study the effect of SRY on the brain. When the esearchers lowered the level of SRY in the substantia nigra, they saw a corresponding drop in an enzyme called tyrosine hydroxylase (TH), which plays a key role in the brain's production of dopamine. In a surprise finding, the drop in TH occurred only in the male rats. The female rats remained unaffected. "When we reduced SRY levels in the rats' brains, the male animals began experiencing the movement problems caused by insufficient dopamine," Vilain said. "Low levels of SRY triggered Parkinson's symptoms in the male rats, cutting their physical agility by half in a week.

Vilain believes that variations in SRY levels may be linked to the onset of Parkinson's and could offer insights into who is at risk for the disease. "SRY may serve as a protective agent against Parkinson's," he said. "Men who contract the disease may have lower levels of the gene in the brain." Because SRY is found only in males, Vilain thinks women must possess another physiological mechanism that protects dopamine-producing cells in the substantia nigra.

"We suspect that estrogens in women could play the same role as SRY in protecting the female brain from Parkinson's disease," he said. "Our lab is currently studying this hypothesis in an animal model."

Sex differences in other dopamine-linked disorders, such as schizophrenia or addiction, may also be explained by the SRY gene. "It's possible that dopamine-related disorders that reveal dramatic differences in severity and rates in the genders could depend on the SRY levels in the brain,"

Researchers Find Molecule That May Hold Key To Learning And Memory

Independent research teams from Harvard Medical School and Children's Hospital Boston have identified a master protein that sheds light on one of neurobiology's biggest mysteries--how neurons change as a result of individual experiences. The research, which appears in two papers in the latest issue of Science (Feb 17), identifies a central protein that regulates the growth and pruning of neurons throughout life in response to environmental stimuli.

This protein, and the molecular pathway it guides, could help investigators understand the process of learning and memory, as well as lead to new therapies for diseases in which synapses either fail to form or run rampant, such as autism, neurodegenerative diseases, and psychiatric disorders.

Though axons and dendrites can be easily spotted waxing and waning under the microscope, the molecular middlemen working inside the cell to shape the neuron's sinewy processes have been much more elusive. The teams found a protein that works in the nucleus of neurons that either pares down or promotes synapses depending on whether or not the neuron is being activated. The protein, myocyte enhancer factor 2 (MEF2), turns on and off genes that control dendritic remodeling. In addition, one of the teams has identified how MEF2 switches from one program to the other, that is, from dendrite-promoting to dendrite-pruning, and the researchers have identified some of MEF2's targets. The uncovering of the MEF2 pathway and its genetic switch helps fill in a theoretical blank in neurobiology, but what excites the researchers are the potential implications for the clinic. "Changes in the morphology of synapses could turn out to be very important in a whole host of diseases including neurodegenerative as well as psychiatric disorders," said Azad Bonni, HMS Associate Professor of Pathology who, with colleagues, authored one of the papers. Michael Greenberg, HMS Professor of Neurology at Children's Hospital Boston, who led the other team, believes that the MEF2 pathway could play a role in autism and other neurodevelopmental diseases.

The protein works by either activating or actively repressing target genes. In working on a group of neurons in the developing rat cerebellum, the study found the MEF2 repressor promoted synaptic differentiation. In a separate study it was found the MEF2 activator inhibited the growth of dendritic spines in the rat hippocampus, an area of the brain associated with memory and learning. Both studies found the activated, or dendrite-whittling, form of MEF2 comes on in response to increased neuronal activity.

That MEF2 activation leads to the inhibition of synapse formation, makes sense in light of what is known about the nervous system. In memory and learning, as well as development, activity leads to a sculpting, or cutting away, of synapses. What may be more surprising is the way activity causes MEF2 to switch from repressor to activator. What this work found is that molecules

modify a particular spot on MEF2, and transform it into a repressor. By removing the modification, known as sumoylation, MEF2 becomes an activator.

MEF2 was first identified in neurons in the 1990s. In 1999, it was showed that MEF2 promotes neuronal survival but little else was known about the protein. Though it was known that MEF2 comes in activated and repressor forms, nobody knew how exactly the protein works.

Taken together, the findings of the two groups might appear puzzling for they seem to say that MEF2 promotes synapse formation by repressing genes and suppresses synapse formation by activating genes. The puzzle resolves itself when one considers the possibility that the genes being turned on and off act to discourage synapse formation. In fact, 2 of MEF2's targets have already been identified: arc and SynGAP. The arc protein appears to play a role in internalizing glutamate receptors, which occurs when dendrites are being disassembled. SynGAP works to turn off the synapse-promoting ras gene. A third target, Nur77, is currently under study. The identification of these targets, and more generally the opening up of the MEF2 pathway, could lead to new therapies for a host of diseases in which synapses either fail to form or run rampant. In fact, Greenberg is currently a member of a consortium that is trying to get at the molecular underpinnings of autism. "We think the MEF2 pathway may be central," he said.

Web program simplifies artificial gene design

A web-based program that simplifies many tricky steps involved in designing artificial DNA has been released by US microbiologists.

The software suite, called GeneDesign, should make it easier for researchers to modify and study DNA. The cost of gene synthesis is rapidly falling with dozens of companies around the world now offering to create genes to order from the chemical components of DNA.

GeneDesign was created by researchers led by Jef Boeke at Johns Hopkins University School of Medicine in Baltimore, US. It simplifies and automates several key steps of DNA design.

These key steps include translating proteins and amino acids – the building blocks which make proteins – backwards into a DNA sequence. Or the software can manipulate simulated DNA "codons" which can code for an amino acid. DNA codons are made of sets of three nucleotides – the fundamental molecules which link together to form a DNA chain

Or the software can be used to identify DNA restriction sites – sections of the DNA which can be spliced or cut in order to mix synthetic and natural DNA.

"The ability to order up any piece of DNA you want is empowering, and the design process itself is quite interesting and gives a totally new perspective," Boeke told.

Safety checks

"It's a really nice tool," says Drew Endy, a bioengineer the Massachusetts Institute of Technology, US. "But you should expect it to be outdated in 18 months."

Endy says the development of more and more advanced gene-design software reflects the increasing technological ease with which genes can be made to order. "We're at this interesting stage where it's becoming easy to synthesise DNA," Endy says. "It is important to have software environments to support this."

But this is also a source of concern. An investigation conducted by **New Scientist** in November 2005, revealed that few gene synthesis companies check that the genes they are being asked to make are safe, or perform customer background checks after receiving an orders.

Entire chromosomes

"Potential for misuse comes with the territory of any powerful new technology," Boeke says. "The synthetic biology community has prided itself on envisioning the darker side of the technology and building in safeguards wherever possible, to minimise the risks associated with gene synthesis technology."

In the face of such worries, Boeke's team would like to introduce safeguards to prevent anyone from using their software to design genes that could be used as a bioweapon. However, Boeke says it is crucial to have access to a regularly updated database of suspect genes.

He believes gene design software will become more and more powerful. "The next scale will be the synthesis of entire chromosomes and genomes," he says.