SCIENCE NEWS

The Future of Plant Science: A Technology Perspective

Plant science is key to addressing the major challenges facing humanity in the 21st Century, according to Carnegie's David Ehrhardt and Wolf Frommer. In a Perspective published in *The Plant Cell*, the two researchers argue that the development of new technology is key to transforming plant biology in order to meet human needs.

Plants serve as the conduit of energy into the biosphere, provide food and materials used by humans and they shape our environment. According to Ehrhardt and Frommer, the three major challenges facing humanity in our time are food, energy and environmental degradation. All three are plant related.

All of our food is produced by plants, either directly or indirectly via animals that eat them. Plants are a source of energy production. And they are intimately involved in climate change and a major factor in a variety of environmental concerns, including agricultural expansion and its impact on habitat destruction and waterway pollution.

What's more, none of these issues are independent of each other. Climate change places additional stresses on the food supply and on various habitats. So plant research is instrumental in addressing all of these problems and moving into the future. For plant research to move significantly forward, Ehrhardt and Frommer say technological development is critical, both to test existing hypotheses and to gain new information and generate fresh hypotheses. If we are to make headway in understanding how these essential organisms function and build the foundation for a sustainable future, then we need to apply the most advanced technologies available to the study of plant life, they say.

They divide the technology into three categories: existing technology that isn't being applied for all

of its potential uses; new, readily envisioned technology and technology we'd like to have, but don't know how to create.

The technological overview includes expanding existing technologies such as DNA sequencing, RNA cataloguing, mass spectroscopy, fluorescence-based microscopy, and electron microscopy, among many others. A key focus is on the advances possible through advanced imaging technologies.

Ehrhardt and Frommer point out that many of the most often-cited academic papers related to the development of new technology, demonstrating the interest of the scientific community. "We certainly expect that new technologies will continue to revolutionise biological research," they say. "Plant science has not often been the driver of innovation but often enough has profited from developments made in other areas."

Lifestyle Choices Made in your 20s can Impact your Heart Health in your 40s

Maintaining a healthy lifestyle from young adulthood into your 40s is strongly associated with low cardiovascular disease risk in middle age, according to a new Northwestern Medicine study.

"The problem is few adults can maintain ideal cardiovascular health factors as they age," said Kiang Liu, first author of the study. "Many middle-aged adults develop unhealthy diets, gain weight and aren't as physically active. Such lifestyles, of course, lead to high blood pressure and cholesterol, diabetes and elevated cardiovascular risk."

Liu is a professor and the associate chair for research in the department of preventive medicine at Northwestern University Feinberg School of Medicine.

"In this study, even people with a family history of heart problems were able to have a low cardiovascular disease risk profile if they started living a healthy lifestyle when they were young," Liu said. "This supports the notion that lifestyle may play a more prominent role than genetics."

Published in the journal *Circulation*, this is the first study to show the association of a healthy lifestyle maintained throughout young adulthood and middle age with low cardiovascular disease risk in middle age.

The majority of people who maintained five healthy lifestyle factors from young adulthood (including a lean Body Mass Index (BMI), no excess alcohol intake, no smoking, a healthy diet and regular physical activity) were able to remain in this low-risk category in their middle-aged years.

In the first year of the study, when the participants' average age was 24 years old, nearly 44 per cent had a low cardiovascular disease risk profile. Twenty years later, overall, only 24.5 per cent fell into the category of a low cardiovascular disease risk profile.

Sixty per cent of those who maintained all five healthy lifestyles reached middle age with the low cardiovascular risk profile, compared with fewer than 5 per cent who followed none of the healthy lifestyles.

Researchers used data collected over 20 years from the Coronary Artery Risk Development in (Young) Adults (CARDIA) study. It began in 1985

and 1986 with several thousand 18 to 30 years olds and has since followed the same group of participants.

For this study, the researchers analysed data such as blood pressure, cholesterol, blood sugar, BMI, alcohol intake, tobacco use, diet and exercise from more than 3,000 of the CARDIA participants to define a low cardiovascular disease risk profile and healthy lifestyle factors.

If the next generation of young people adopt and maintain healthy lifestyles, they will gain more than heart health, Liu stressed.

"Many studies suggest that people who have low cardiovascular risk in middle age will have a better quality of life, will live longer and will have lower Medicare costs in their older age," he said. "There are a lot of benefits to maintaining a low-risk profile."

The National Heart, Lung and Blood Institute and the National Institutes of Health funded this research.

When One Side Does not Know about the Other One: Specialisation and Cooperation of the Brain Hemispheres

Whenever we are doing something, one of our brain hemispheres is more active than the other one. However, some tasks are only solvable with both sides working together. Dr Martina Manns and Juliane Römling of the Ruhr-Universität Bochum are investigating, how such specialisations and co-operations arise. Based on a pigeon-model, they are demonstrating for the first time in an experimental way, that the ability to combine complex impressions from both hemispheres, depends on environmental factors in the embryonic stage.

The results of the study are published online in *Nature Communications*.

Biased light stimulation

Within the egg bird embryos always turn their head in such a way that one eye is turned close to the eggshell, and the other one is covered by the body. This causes an asymmetrical light stimulation, which influences developmental processes in both brain halves. Dr Manns uses this mechanism for her experiment. One group of embryos hatch in a lighted incubator, another one in complete darkness. Afterwards the scientists analyse the degree of interhemispheric communication in both groups. The results show that information exchange is impaired without light stimulation. This research sheds light on the origin of communication processes in the brain. Developmental disorders like ADHD or autism are characterised by a deviating pattern between the two brain halves. Therefore, there is a possibility that the results may help to understand those disorders and give hints for new therapeutic approaches.

Classification of colour-pairs

To determine how efficient the animals are able to handle incoming information, Manns and Römling confront the animals with a task that can only be solved with both brain hemispheres working together. For that purpose, the two psychologists use colour-pairs of a transitive line(A→B→C→D→E) at which one of the elements is rewarded with food. First the pigeons

have to learn to discriminate the combinations A/B and B/C with one eye, and C/D and D/E with the other one. Afterwards, they can use both eyes to decide between, for example, the colours B/D. However, only birds with embryonic light experience are able to solve this problem.

First Computer Model of How Buds Grow into Leaves

Leaves come in all shapes and sizes. Scientists have discovered simple rules that control leaf shape during growth. Using this 'recipe', they have developed the first computer model able to accurately emulate leaf growth from a bud.

"A bud does not grow in all directions at the same rate," said Samantha Fox from the John Innes Centre on Norwich Research Park. "Otherwise leaves would be domed like a bud, not flat with a pointed tip."

By creating a computer model to grow a virtual leaf, the BBSRC-funded scientists managed to discover simple rules of leaf growth.

Similar to the way a compass works, plant cells have an inbuilt orientation system. Instead of a magnetic field, the cells have molecular signals to guide the axis on which they grow. As plant tissues deform during growth, the orientation and axis changes.

The molecular signals become patterned from an early stage within the bud, helping the leaf shape to emerge.

The researchers filmed a growing *Arabidopsis* leaf, a relative of oil seed rape, to help create a model which could simulate the growing process. They were able to film individual cells and track them as the plant grew.

It was also important to unpick the workings behind the visual changes and to test them in normal and mutant plants.

"The model is not just based on drawings of leaf shape at different stages," said Professor Enrico Coen. "To accurately recreate dynamic growth from bud to leaf, we had to establish the mathematical rules governing how leaf shapes are formed."

With this knowledge programmed into the model, developed in collaboration with Professor Andrew Bangham's team at the University of East Anglia, it can run independently to build a virtual but realistic leaf.

Budding leaves. (Credit: John Innes Centre)

Professor Douglas Kell, Chief Executive of BBSRC said: "This exciting research highlights the potential of using computer and mathematical models for biological research to help us tackle complex questions and make predictions for the

future. Computational modelling can give us a deeper and more rapid understanding of the biological systems that are vital to life on earth."

The model could now be used to help identify the genes that control leaf shape and whether different genes are behind different shapes.

"This simple model could account for the basic development and growth of all leaf shapes," said Fox. "The more we understand about how plants grow, the better we can prepare for our future — providing food, fuel and preserving diversity."

Developing Sustainable Power

The invention of a long-lasting incandescent light bulb in the 19th century spurred on the second wave of the industrial revolution, illuminating homes, extending leisure time and bringing us to the point today where many millions of people use a whole range of devices from mood lighting to audiovisual media centres, microwave ovens to fast-freeze ice makers, and allergy-reducing vacuum cleaners to high-speed broadband connected computers in their homes without a second thought.

However, the waves of the industrialisation of the west have merely lapped at the shores of undeveloped regions and it is estimated that about a quarter of the world's population, particularly those in rural parts of the developing world do not have access to electricity in their homes. Indeed, four-fifths of those without domestic electricity live in rural or on the urban margins. In sub-Saharan Africa, the proportion is even more startling where just 8 per cent of the rural population has access to electricity.

Those in the developing countries are thus keen to electrify and need stable sources of power to stimulate development and improve their standard of living. The developed world is gradually recognising the environmental costs of widespread electricity use, yet has neither the right nor the authority to deprive the developing nations of power. There is a need, therefore, to provide 100 per cent off-grid zero-energy solutions that require little or no government involvement and are low maintenance. This would allow the developing world to wade into the technology, the developed world enjoys without making the same woefully polluting mistakes regarding unsustainable power generation that are now a global problem.

Benedict Ilozor and Mohammed Kama of the Eastern Michigan University, in Ypsilanti, USA, suggest that renewable energy is a viable option for electrical power in developing and emerging nations. Writing in the inaugural issue of the *African Journal of Economic and Sustainable Development*, they point out that in most of these nations, the demand for energy far exceeds the generating capacity. They suggests that a rapid response to this huge demand that is informed by social, political, economic, climatic and environmental factors must be put in place so that renewable, sustainable energy supply can be identified.

The researchers have undertaken a case study of Nigeria in West Africa, which is perhaps representative of the situation prevalent in most developing and emerging nations. They suggest that cost is the limiting factor and that communities and governments would be unable to subsidise neither the one-time installation

costs nor the ongoing maintenance however low, for most renewable energy solutions. It is, they say up to the private sector and commercial banks, and perhaps charitable organisations, to fund the installation of wind turbines, solar panels and other renewable energy systems so that wealth-generating development can take place and standards of living raised quickly. They posit the idea of a renewable energy mortgage that would be paid back as the specific region developed and grew economically. There are many approaches to solar power, for instance, that could be implemented by individual households or small communities for domestic electricity as well as on a larger scale, while geothermal systems could be run to provide the power for cooling.

Predicting Children's Language Development

We depend on a barrage of standardised tests to assess everything from aptitude to intelligence. But do they provide an accurate forecast when it comes to something as complex as language? A study by Diane Pesco, an assistant professor in Concordia's Department of Education, and co-author Daniela O'Neill, published earlier this year in the *Journal of Speech, Language, and Hearing Research*, shows that the Language Use Inventory (LUI) does.

Developed by O'Neill at the University of Waterloo, the LUI assesses the language of children 18 to 47 months old. In answering a series of questions, parents reveal how their children use language in various situations, including interacting with others, playing and communicating about the world around them. Children's scores can then be compared to those of hundreds of other children the same age from across Canada. In fact, the test is currently used in eight provinces in Canada, 30 states in the U.S., as well as in the U.K., Ireland, Australia and New Zealand.

When Pesco and O'Neill began their study, O'Neill had already established that the LUI can accurately assess a child's current language ability, but the measure's relative novelty meant that its ability to accurately predict how toddlers would fare as they blossomed into youngsters could not be assessed until now.

Pesco, who is also a certified speech-language pathologist, was eager to see if the LUI results would hold down the line and perhaps result in fewer false positives than other measures of young children's language.

"False positives," Pesco explains, "means that a measure identifies a child as having a language delay or problem when, in fact, he or she does not. That's a problem, since services for children with true delays are already overtaxed and have long waiting lists. False positives can also lead parents to worry unnecessarily and to incur expenses for private services and can cause stress for children. At the same time, we don't want to miss children who have and may continue to have difficulties."

Finding a measure that can accurately identify children with language issues and that can predict who will continue to have difficulties later in childhood has, therefore, become a common goal for researchers, speech pathologists, paediatricians and parents who want to ensure that their kids develop strong language skills.

In response to this challenge, Pesco and O'Neill analysed data from 348 five- to six-year-olds whose parents had completed the LUI when their child was a toddler or pre-schooler. The two researchers examined the relationship between the children's scores on the LUI and on later language measures.

The results were promising. Children who had scored low on the LUI as toddlers were far more likely to have low scores on language measures when they hit five or six. These same children were also likely to be identified with a language impairment by the time they hit school age.

According to the study's findings, therefore, the LUI can both identify kids who are struggling with language now and provide insight into their future facility with words. Early identification of language delays permits parents to seek help before problems set in, potentially resulting in a brighter future for those children whose language skills need a boost.

Stress Changes how People Make Decisions

Trying to make a big decision while you're also preparing for a scary presentation? You might want to hold off on that. Feeling stressed changes how people weigh risk and reward. A new article published in *Current Directions in Psychological Science*, a journal of the Association for Psychological Science, reviews how, under stress, people pay more attention to the upside of a possible outcome.

It's a bit surprising that stress makes people focus on the way things could go right, says Mara Mather of the University of Southern California, who cowrote the new review paper with Nichole R. Lighthall. "This is sort of not what people would think right off the bat," Mather says. "Stress is usually associated with negative experiences, so you'd think, maybe I'm going to be more focused on the negative outcomes."

But researchers have found that when people are put under stress — by being told to hold their hand in ice water for a few minutes, for example, or give a speech — they start paying more attention to positive information and discounting negative information. "Stress seems to help people learn from positive feedback and impairs their learning from negative feedback," Mather says.

This means when people under stress are making a difficult decision, they may pay more attention to the upsides of the alternatives they're considering and less to the downsides. So someone who's deciding whether to take a new job and is feeling stressed by the decision might weigh the increase in salary more heavily than the worse commute.

The increased focus on the positive also helps explain why stress plays a role in addictions, and people under stress have a harder time controlling their urges. "The compulsion to get that reward comes stronger and they're less able to resist it," Mather says. So a person who's under stress might think only about the good feelings they'll get from a drug, while the downsides shrink into the distance.

Stress also increases the differences in how men and women think about risk. When men are under stress, they become even more willing to take risks; when women are stressed, they get

more conservative about risk. Mather links this to other research that finds, at difficult times, men are inclined toward fight-or-flight responses, while women try to bond more and improve their relationships.

"We make all sorts of decisions under stress," Mather says. "If your kid has an accident and ends up in the hospital, that's a very stressful situation and decisions need to be made quickly." And, of course, big decisions can be sources of stress all by themselves and just make the situation worse. "It seems likely that how much stress you're experiencing will affect the way you're making the decision."

How the Brain Responds to Deceptive Advertising

Several specific regions of our brains are activated in a two-part process when we are exposed to deceptive advertising, according to new research conducted by a North Carolina State University professor. The work opens the door to further research that could help us understand how brain injury and aging may affect our susceptibility to fraud or misleading marketing.

The study utilised functional Magnetic Resonance Imaging (fMRI) to capture images of the brain while study participants were shown a series of print advertisements. The fMRI images allowed researchers to determine how consumers' brains respond to potentially deceptive advertising. "We did not instruct participants to evaluate the ads. We wanted to mimic the passive exposure to advertising that we all experience everyday," says Dr Stacy Wood, Langdon Distinguished professor of Marketing at NC State and co-author of a paper describing the research.

Participants were exposed to three pre-tested advertisements that were deemed "highly believable," "moderately deceptive" or "highly deceptive." The ads were also pre-tested to ensure that they were for products that consumers found equally interesting and desirable — leaving the degree of deception as the only significant variable.

"We found that people have a two-stage process they go through when confronted with moderately or highly deceptive ads," Wood says.

During the first stage, researchers saw increased activity in the precuneus — a part of the brain associated with focusing conscious attention. "We found that the more deceptive an advertisement is, the more you are drawn to it," Wood says, "much as our attention is drawn to potential threats in our environment." Specifically, in this study, the more deceptive an ad was, the more precuneus activity was observed.

During the second stage, researchers saw more activity in the Superior Temporal Sulcus (STS) and Tempero-Parietal Junction (TPJ) regions of the brain. This suggests increased "Theory-of-Mind" (ToM) reasoning. ToM is a type of processing that allows us to distinguish our wants and needs from those of others, particularly as this applies to intuiting the intentions of other people. In this case, it appears to indicate that participants were trying to determine the truth behind the claims in the potentially deceptive advertisements.

"What's interesting here is that the moderately deceptive ads cause more activity during this second stage," Wood says. That may be because highly deceptive ads are screened out more quickly and discarded as not meriting further attention.

Overall, when looking at both stages of brain response, researchers found there was greater brain activation when participants were exposed to moderately deceptive ads. But, if moderately deceptive ads stimulate more brain activity, does that make us more susceptible to the sales pitch in ads that trigger just a pinch of skepticism?

Apparently not. In a follow-up, behavioural component of the study, researchers interfered with the ToM stage, making it more difficult for participants to determine the intention behind the ads. As a result, participants more frequently believed moderately deceptive advertising. This suggests that the second stage is an important step that helps protect consumers by allowing them to better discriminate and screen out deceptive ads.

"Now that we've identified these stages of brain response, it may help future researchers identify underlying neural reasons why some populations are more prone to fall prey to deceptive ads," Wood says. "For example, if these regions of the brain are likely to be affected by aging, it may explain why older adults are more vulnerable to fraud or deceptive advertising. Or how might concussive brain injuries, such as those seen in some sports, affect our long-term discrimination in making good consumer choices?"

The paper, "Suspicious Minds: An fMRI Investigation of How Consumers Perceive Deception in the Marketplace," was co-authored by Wood, Dr Adam Craig of USF (lead researcher), Dr Yuliya Loureiro of Fordham and Dr Jennifer Vendemia of USC. The paper is published online in the *Journal of Marketing Research*.

World's Smallest Radio Stations: Two Molecules Communicate via Single Photons

We know since the dawn of modern physics that although events in our everyday life can be described by classical physics, the interaction of light and matter is down deep governed by the laws of quantum mechanics. Despite this century-old wisdom, accessing truly quantum mechanical situations remains non-trivial, fascinating and noteworthy even in the laboratory. Recently, interest in this area has been boosted beyond academic curiosity because of the potential for more efficient and novel forms of information processing.

In one of the most basic proposals, a single atom or molecule acts as a quantum bit that processes signals that have been delivered via single photons. In the past twenty years, scientists have shown that single molecules can be detected and single photons can be generated. However, excitation of a molecule with a photon had remained elusive because the probability that a molecule sees and absorbs a photon is very small. As a result, billions of photons per second are usually impinged on a molecule to obtain a signal from it.

One common way to get around this difficulty in atomic physics has been to build a cavity around the atom so that a photon remains trapped for long enough times to yield a favourable interaction probability. Scientists at ETH Zurich and Max Planck Institute for the Science of Light in Erlangen have now shown that one can even interact a flying photon with a single molecule.

Among many challenges in the way of performing such an experiment is the realisation of a suitable source of single photons, which have the proper frequency and bandwidth. Although one can purchase lasers at different colours and specifications, sources of single photons are not available on the market.

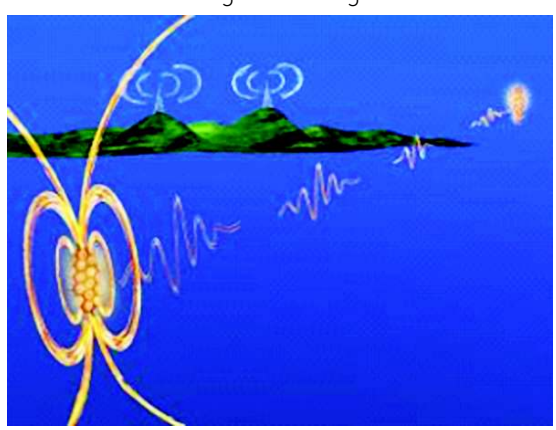
So a team of scientists led by Professor Vahid Sandoghdar made its own. To do this, they took advantage of the fact that when an atom or molecule absorbs a photon it makes a transition to a so-called excited state. After a few nanoseconds (one thousand millionth of a second) this state decays to its initial ground state and emits exactly one photon. In their experiment, the group used two samples containing fluorescent molecules embedded in organic crystals and cooled them to about 1.5 K (-272 °C). Single molecules in each sample were detected by a combination of spectral and spatial selection.

To generate single photons, a single molecule was excited in the "source" sample. When the excited state of the molecule decayed the emitted photons were collected and tightly focused onto the "target" sample at a distance of a few meters. To ensure that a molecule in that sample "sees" the incoming photons, the team had to make sure that they have the same frequency. Furthermore, the precious single photons had to interact with the target molecule in an efficient manner. A molecule is about one nanometer is size (1,00,000 times smaller than the diameter of a human hair) but the focus of a light beam cannot be smaller than a few hundred nanometers.

This usually means that most of the incoming light goes around the molecule, i.e., without them seeing each other. However, if the incoming photons are resonant with the quantum mechanical transition of the molecule, the latter acts as a disk that is comparable to the area of the focused light. In this process, the molecule acts as an antenna that grabs the light waves in its vicinity. The results of the study published in *Physical Review Letters* provide the first example of long-distance communication between two quantum optical antennas in analogy to the 19th century experiments of Hertz and Marconi with radio antennas. In those early efforts, dipolar oscillators were used as transmitting and receiving antennas.

In the current experiment, two single molecules mimic that scenario at optical frequencies and via a non-classical optical channel, namely a single photon stream. This opens many doors for further exciting experiments in which single photons act as carriers of quantum information to be processed by single emitters.

The experimental work was performed at ETH Zurich before the group of Professor Sandoghdar moved to the newly founded Max Planck Institute for the Science of Light in Erlangen in 2011.



Artist's view of a single molecule sending a stream of single photons to a second molecule at a distance, in quantum analogy to the radio communication between two stations. (Credit: Robert Lettow)

Future Smart Phones will Project Images on the Wall

Mobile phones currently on the market are capable of showing high quality images and video, but the phones' small size sets insurmountable limits on screen size, and thus the viewing experience. VTT Technical Research Centre of Finland, EpiCrystals Oy and the Aalto University are developing a better laser light source for projectors that will be integrated into mobile phones, which will enable accurate and efficient projection of, for example, photographs and movies on any surface. Mobile phones equipped with the laser light source can be within the ordinary consumer's reach already in a few years time.

Small-size laser projectors 1-2 centimetres in length can be integrated into many kinds of electronic appliances, such as digital or video cameras, gaming devices and mobile phones. Integrated micro projectors could, in practice, project images the size of an A3 sheet of paper on a wall.

The challenge is to develop a small, energy-efficient and luminous three-colour (RGB) light source, whose manufacturing costs can be kept low, for use in the projectors. Solutions for these challenges are sought in a project combining Finnish know-how, whose parties are VTT, EpiCrystals Inc. and the Aalto University.

"The project has successfully combined multi-technological know-how from VTT and its partners in the project, from manufacturing materials and the accurate focusing of laser chips all the way to production line design. The project was launched last autumn, and we are now entering the stage where we can move from brainstorming and design to building prototypes. It is our goal to prove by next summer that large quantities of the new laser light sources can be manufactured quickly and economically ," says Principal Scientist Timo Aalto from VTT.

EpiCrystals Inc. aims straight for the global market with its product, and it is the company's goal to be the technology and market leader in laser light sources for micro projectors by 2015.

"We are developing an entirely new technology that is currently not in use anywhere else in the world. At the moment, there are stand-alone projectors on the market that can be connected to electronic appliances and early stage integrated projectors, but their quality and price are not competitive enough. Large electronics manufacturers are extremely interested in integrated projectors, and market research shows that demand for these micro projectors will increase strongly in the coming years. Soon, around two billion mobile phones per year will be sold in the world, and if even a couple of per cent of those contain a projector, we are talking about tens of millions of copies, and the hundred million mark is not far either," says Vice President of Business Development Tomi Jouhti of EpiCrystals Oy.

EpiCrystals' laser modules will be mass-produced in Asia, but the research and development will remain in Finland also in the future. The VTT, EpiCrystals and Aalto University project has received funding from the Finnish Funding Agency for Technology and Innovation Tekes, among others.

Research Offers Insight to how Fructose Causes Obesity and other Illness

A group of scientists from across the world have come together in a just-published study that provides new insights into how fructose consumption results in obesity and metabolic syndrome, which can lead to diabetes. In this study which was performed in lab animals, researchers found that fructose can be metabolised by an enzyme that exists in two forms. One form appears to be responsible for causing how fructose causes fatty liver, obesity, and insulin resistance. The other form may actually protect animals from developing these features in response to sugar.

These studies may provide important insights into the cause of the pre-diabetic condition known as "metabolic syndrome," which currently affects more than one-quarter of adults in the United States.

The study, "Opposing effects of fructokinase C and A isoforms on fructose-induced metabolic syndrome in mice" was just published in the journal *Proceedings of the National Academy of Sciences*. Richard Johnson, MD, the senior author of the study and Chief of the Division of Renal Diseases and Hypertension at the University of Colorado School of Medicine said the findings are significant because we now have a better understanding of how fructose causes obesity and other illnesses.

"These studies provide new insights into how fructose may contribute to the development of obesity and diabetes. In particular, the identification of contrasting roles for two enzymes that are involved in fructose metabolism was surprising and could be important in understanding why some individuals may be more sensitive to the metabolic effects of fructose than others."

Previous research has shown that fructose intake in added sugars such as sucrose and high fructose corn syrup is strongly linked to the epidemic rise in obesity and non-alcoholic fatty liver disease. Fructose intake also causes features of metabolic syndrome in laboratory animals and humans. It is known to cause visceral (organ) fat accumulation and insulin resistance compared to starch-based diets even when calories are kept even.

Faculty at the University of Colorado School of Medicine work to advance science and improve care. These faculty members include physicians, educators and scientists at University of Colorado Hospital, Children's Hospital Colorado, Denver Health, National Jewish Health, and the Denver Veterans Affairs Medical Centre. Degrees offered by the CU Denver School of Medicine include doctor of medicine, doctor of physical therapy, and masters of physician assistant studies.

60-Year-Old Definition of Surface Tension on Solids Revised

Researchers of VTT Technical Research Centre of Finland have shown that surface tension on a solid material is unconnected to the energy required to create a new surface. Consequently, surface tension on a solid does not exist in its conventional meaning.

It is generally believed that an excess surface tension on a solid material exists, in similar manner to that on a liquid. This tension is described by the Shuttleworth equation, which was presented more than 60 years ago and is considered a fundamental equation of surface thermodynamics. It is believed to provide the connection between surface tension and surface energy.

Three years ago, VTT researchers Lasse Makkonen and Kari Kolari, together with British scientist David Bottomley, revealed in the Surface Science journal that the Shuttleworth equation is incompatible with the thermodynamic theory. This was hard to accept by many and provoked a lively discussion in the scientific literature.

Now Lasse Makkonen has shown mathematically that the disputed equation reduces to the definition of mechanical surface stress and has no connection with the energy of creating a new, unstrained surface. Consequently, the excess surface tension suggested by the Shuttleworth equation does not exist. The existence and nature of surface tension on a solid must, therefore, be sought by molecular dynamics at the surface layer only.

Liquid-like Materials may Pave Way for New Thermoelectric Devices

In the continual quest for better thermoelectric materials — which convert heat into electricity and vice versa — researchers have identified a liquid-like compound whose properties give it the potential to be even more efficient than traditional thermoelectrics.

Thermoelectric materials have been used to power spacecraft ranging from Apollo to the Curiosity rover now headed for Mars. Recently, however, scientists and engineers have been turning to these materials to use wasted heat — released from automobiles or industrial machinery, for instance — as an efficient energy source. They have also proposed using these materials to create more efficient heating systems in electric cars or even as new ways to exploit solar power.

In identifying this new type of thermoelectric material, the researchers studied a material made from copper and selenium. Although it is physically a solid, it exhibits liquid-like behaviours due to the way its copper atoms flow through the selenium's crystal lattice.

"It's like a wet sponge," explains Jeff Snyder, a faculty associate in applied physics and materials science in the Division of Engineering and Applied Science at the California Institute of Technology (Caltech) and a member of the research team. "If you have a sponge with very fine pores in it, it looks and acts like a solid. But inside, the water molecules are diffusing just as fast as they would if they were a regular liquid. That's how I imagine this material works. It has a solid framework of selenium atoms, but the copper atoms are diffusing around as fast as they would in a liquid."

The research, led by scientists from the Chinese Academy of Science's Shanghai Institute of Ceramics in collaboration with researchers from Brookhaven National Laboratory and the University of Michigan, as well as from Caltech, is described in a paper recently published in the journal *Nature Materials*.

A thermoelectric material generates electricity when there is a temperature difference between one end of the material and the other. For example, if you place a thermoelectric device right next to a heat source — say a laptop battery — then the side closest to the battery will be hotter. The electrons in the hot end will diffuse to the cool end, producing an electric current.

A good thermoelectric material must be good at conducting electricity but bad at conducting heat. If it were good at conducting heat, the heat from the hot end would move to the cool end so fast that the whole material would rapidly reach the same temperature. When that happens, the electrons stop flowing.

One way to improve thermoelectric efficiency, then, is to decrease a material's ability to conduct heat. To that end, researchers have been developing thermoelectric materials with a mix of crystalline and amorphous properties, Snyder says. A crystalline atomic structure allows electrons to flow easily, while an amorphous material, such as glass, has a more irregular atomic structure that hinders heat-carrying vibrations from travelling.

These heat-carrying vibrations travel via two types of waves. The first type is a longitudinal or pressure wave, in which the direction of displacement — in this case, the jiggling of atoms — is the same as the direction of the wave. The second type is a transverse wave, in which the direction of displacement is perpendicular to the direction of the wave, like when you shake a jump rope up and down, resulting in waves that travel horizontally along the rope.

In a solid material, a transverse wave travels because there is friction between the atoms, meaning that when one atom vibrates up and down, an adjacent atom moves with it, and the wave propagates. But in a liquid, there is minimal friction between the atoms, and a vibrating atom just slides up and down next to its neighbour. As a result, transverse waves cannot travel inside a liquid. Ocean waves are different because they have an interface between the liquid and the air.

The team found that because heat-carrying vibrations in a liquid can travel only via longitudinal waves, a material with liquid-like properties is less thermally conductive. Therefore, a liquid-like material that's also good at conducting electrically should be more thermoelectrically efficient than traditional amorphous materials, Snyder says.

In the case of the copper-selenium material that the researchers studied, the crystal structure of the selenium helps conduct electricity, while the free-flowing copper atoms behave like a liquid, damping down thermal conductivity. The efficiency of a thermoelectric material is quantified using a number called a "thermoelectric figure of merit." The copper-selenium material has a thermoelectric figure of merit of 1.5 at 1000 degrees Kelvin, one of the highest values in any bulk material, the researchers say.

NASA engineers first used this copper-selenium material roughly 40 years ago for spacecraft design, Snyder says. But its liquid-like properties — which were not understood at the time — made it difficult to work with. This new research, he says, has identified and explained why this copper-selenium material has such efficient thermoelectric properties, potentially

opening up a whole new class of liquid-like thermoelectric materials for investigation.

"Hopefully, the scientific community now has another strategy to work with when looking for materials with a high thermoelectric figure of merit," Snyder says.

In addition to Snyder, the research group includes Caltech graduate student Tristan Day. The other authors on the *Nature Materials* paper, titled "Copper ion liquid-like thermoelectrics," are Huili Liu, Xun Shi, Lidong Chen, Fangfang Xu,

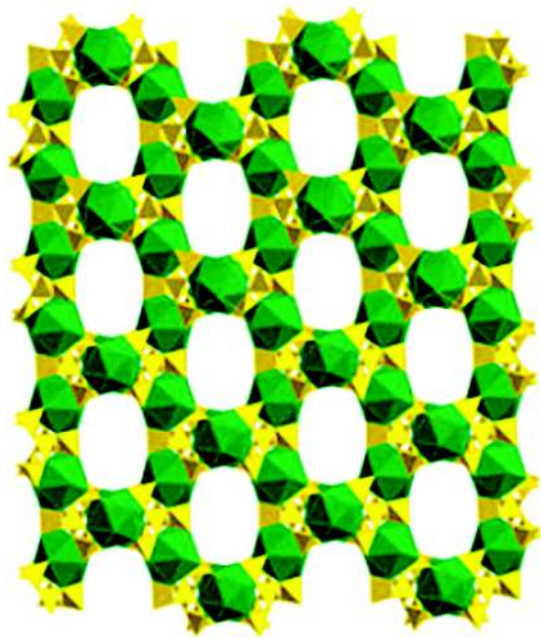
Linlin Zhang, and Wenqing Zhang of the Chinese Academy of Science's Shanghai Institute of Ceramics; Qiang Li of Brookhaven National Laboratory and Citrad Uher of the University of Michigan.

New Method for Cleaning up Nuclear Waste

While the costs associated with storing nuclear waste and the possibility of it leaching into the environment remain legitimate concerns, they may no longer be obstacles on the road to cleaner energy.

A new paper by researchers at the University of Notre Dame, led by Thomas E. Albrecht-Schmitt, professor of civil engineering and geological sciences and concurrent professor of chemistry and biochemistry, showcases Notre Dame Thorium Borate-1 (NDTB-1) as a crystalline compound that can be tailored to safely absorb radioactive ions from nuclear waste streams. Once captured, the radioactive ions can then be exchanged for higher-charged species of a similar size, recycling the material for re-use.

If one considers that the radionuclide technetium (99Tc) is present in the nuclear waste at most storage sites around the world, the math becomes simple. There are more than 436 nuclear power plants operating in 30 countries; that is a lot of nuclear waste. In fact, approximately 305 metric tons of 99Tc were generated from nuclear reactors and weapons testing from 1943 through 2010. Its safe storage has been an issue for decades.



(NDTB-1) as a crystalline compound that can be tailored to safely absorb radioactive ions from nuclear waste streams. (Credit: Image courtesy of University of Notre Dame)

"The framework of the NDTB-1 is key," says Albrecht-Schmitt. "Each crystal contains a framework of channels and cages featuring billions of tiny pores, which allow for the

interchange of anions with a variety of environmental contaminants, especially those used in the nuclear industry, such as chromate and pertechnetate."

Albrecht-Schmitt's team has concluded successful laboratory studies using the NDTB-1 crystals, during which they removed approximately 96 per cent of 99Tc. Additional field tests conducted at the Savannah River National Laboratory in Aiken, S.C., and discussed in the paper have shown that the Notre Dame compound successfully removes 99Tc from nuclear waste and also exhibits positive exchange selectivity for greater efficiency.

Solving the Mystery of Blood Clotting

How and when our blood clots is one of those incredibly complex and important processes in our body that we rarely think about. If your blood doesn't clot and you cut yourself, you could bleed to death, if your blood clots too much, you could be in line for a heart attack or stroke. Hans Vogel, a professor at the University of Calgary, has thought a lot about blot clotting and recently published research in the *Journal of the American Chemical Society* that helps to better understand the clotting process.

Vogel and his graduate student Hao Huang were able to determine the molecular 3D structure of a protein in blood platelets and a receptor that sticks through the membrane of the cell to the outside. Platelets are tiny cells specialised for clotting reactions. The receptor protein is unique for platelets and directly controls blood clot formation. Other scientists have unsuccessfully attempted to map this structure, but Huang and Vogel were the first to make it work.

"The goal of the research is to provide a molecular level understanding of the blood clot regulatory process," says Vogel of the Department of Biological Sciences in the Faculty of Science. "Eventually the long term goal is to interfere in that, although one has to be extremely careful with such a delicate process. Often times, these molecular structures are useful for pharmaceutical companies and for follow-up research projects that take them as a starting point to develop new drugs."

This particular piece of research is also related to Vogel's lab's larger goal, which is to figure out how our body responds to foreign invasions of bacteria, particularly in relation to superbugs that aren't treatable by antibiotics. "You don't really want to have an infection starting in and around a blood clot," says Vogel. "So once a platelet is lodged into position, it releases all sorts of proteins and then it attracts all these factors that are antimicrobial. Platelets get together with white blood cells and together they orchestrate a really important antimicrobial response."

The next step in Vogel's research is to try to find out more about this antimicrobial response and build on it. "A lot of science is putting pieces into a large puzzle," says Vogel. "I've been involved in active research for 30 years. If you look over your career, then you make many incremental steps forward, but everything together builds a big picture. The paper we recently published proved to be a very important piece of the puzzle." Vogel's research in this area is supported by Alberta Innovates Health Solutions and the Canadian Institutes for Health Research.

3-D Microscopy to Aid in Cell Analysis

The understanding of diseases such as Parkinson's and Alzheimer's is set to take a step forward following groundbreaking technology which will enable cell analysis using automated 3D microscopy.

An initiative between the Griffith's School of Information Communication Technology and the Eskitis Institute for Cellular and Molecular Biology, the technology will allow the automated identification, separation and analysis of cells as complex as nerve cells in the brain.

"Scientists and clinicians will be able to superimpose multiple data sets in three dimensions using automated techniques and then conduct detailed analysis of the data in a far improved way from the two-dimensional microscopy that is currently available," said Dr Adrian Meedeniya, manager of Griffith's Imaging and Image Analysis Facility.

Microscopy and image acquisition technology has undergone a recent revolution, with modern microscopes generating huge multi-dimensional data-sets that can easily fill an entire hard drive. Manually analysing these data-sets is incredibly time-consuming and prone to human error and bias.

"One of the main motivations for establishing this collaboration with the School of ICT was to create the technology to efficiently deal with these huge data-sets," Dr Meedeniya said.

"We will be able to use this technology to rapidly increase our understanding of the way neuro-degenerative disorders affect nerve cell function in the brain."

Underpinned by neural network algorithms (artificial intelligence), the cutting-edge technology is expected to be widely used in disease research within a matter of a few years.

Ph.D. candidate Gervase Tuxworth who is involved with the technology. (Credit: Image courtesy of Griffith University)

Right Hand or Left? How the Brain Solves a Perceptual Puzzle

When you see a picture of a hand, how do you know whether it's a right or left hand? This "hand laterality" problem may seem obscure, but it reveals a lot about how the brain sorts out confusing perceptions. Now, a study which will be published in a forthcoming issue of *Psychological Science*, a journal published by the Association for Psychological Science, challenges the long-held consensus about how we solve this problem.

"For decades, the theory was that you use your motor imagination," says Shivakumar Viswanathan, who conducted the study with University of California Santa Barbara colleagues Courtney Fritz and Scott T. Grafton. Judging from response times, psychologists thought we imagine flipping a mental image of each of our own hands to find the one matching the picture. These imagined movements were thought to

recruit the same brain processes used to command muscles to move — a high-level cognitive feat.

The study, however, finds that the brain is adept at decoding a left or right hand without these mental gymnastics. Judging laterality is "a low-level sensory problem that uses processes that bring different senses into register" — a process called binding, says Viswanathan. Seeing a hand of unknown laterality leads the brain to bind the seen hand to the correct felt hand. If they are still out of register because of their conflicting positions, an illusory movement arises from the brain's attempt to bring the seen and felt hand into the same position. But "this feeling of moving only comes after you already know which hand it is."

In the study, participants couldn't see their own hands, which were held palm down. They saw hand shapes tilted at different angles, with a coloured dot on them indicating a palm-up or down posture. One group of participants saw the shape first and then the dot; and the other, the dot first. Participants in both groups put the shape and dot together mentally and indicated which hand it was by pushing a button with that hand. However, when the shape and dot were shown simultaneously, participants in the first group felt movements of their right hands when seeing a left hand and vice versa; the other group always felt a movement of the correct hand. This behavioural difference (which experimenters gleaned from response time) was due to differences in participants' perception of the seen hand — establishing that an earlier sensory process made the decision.

In a second experiment, participants were told which hand it was and had to judge whether its palm was down or up, indicating their answer with one hand only. This time, the illusory hand-movement occurred only when the seen hand-shape matched that of the participant's own palm-down responding hand, but not otherwise. Even though no right/left judgements were required, the response was dominated by an automatic binding of the seen and felt hands, and the illusory movement followed, says Viswanathan.

The study helps us understand the experience of amputees, who sometimes sense an uncontrollable itch or clenching in the "phantom" body part. Showing the opposite hand or leg in a mirror allows the patient to "feel" the absent limb and mentally relieve the discomfort — a "binding" of vision and feeling.

When you see a picture of a hand, how do you know whether it's a right or left hand? (Credit: © Christian Schwier / Fotolia)

Precision Time: A Matter of Atoms, Clocks and Statistics

The ability to accurately measure a second in time is at the heart of many essential technologies; the most recognisable may be the Global Positioning System (GPS). In a paper accepted for publication in the AIP's journal Review of Scientific Instruments, Judah Levine, a researcher at the National Institutes of Standards and

Technology (NIST) and the University of Colorado at Boulder discusses how achieving a stable and coordinated global measure of time requires more than just the world's most accurate timepieces; it also requires approximately 400 atomic clocks working as an ensemble.

According to Levine, however, calculating the average time of an ensemble of clocks is difficult, and complicated statistics are needed to achieve greater accuracy and precision. These statistical calculations are essential to help counter one of the most important challenges in keeping and agreeing on time: distributing data without degrading the performance of the source clocks.

All atomic clocks operate in basically the same way, by comparing an electrical oscillator (a device engineered to keep time) with the transition frequency of an atom (one of nature's intrinsic time keepers). This atomic transition is a "flip" in the spin in the outermost electron of an atom — an event that is predictable with an accuracy of a few parts per ten quadrillion. Comparing the natural and engineered signals produces the incredibly stable "tick" of an atomic clock.

Several algorithms are then used to estimate the time of the reference clock with respect to the ensemble of clocks. These calculations weed out as much error as possible and establish a reliable reference time. Levine notes that there are strengths and weaknesses in each of these statistical steps, but these weaknesses can be mitigated to some extent by also including retrospective data. So in essence, determining the current time relies on understanding how accurately researchers were able to calculate time in the past.

Even the next generation of atomic clocks and frequency standards are unlikely to eliminate the need for these timescale algorithms. However, keeping time and frequency signals and standards the same in all countries is essential and greatly simplifies international cooperation in areas such as navigation, telecommunication and electric power distribution.