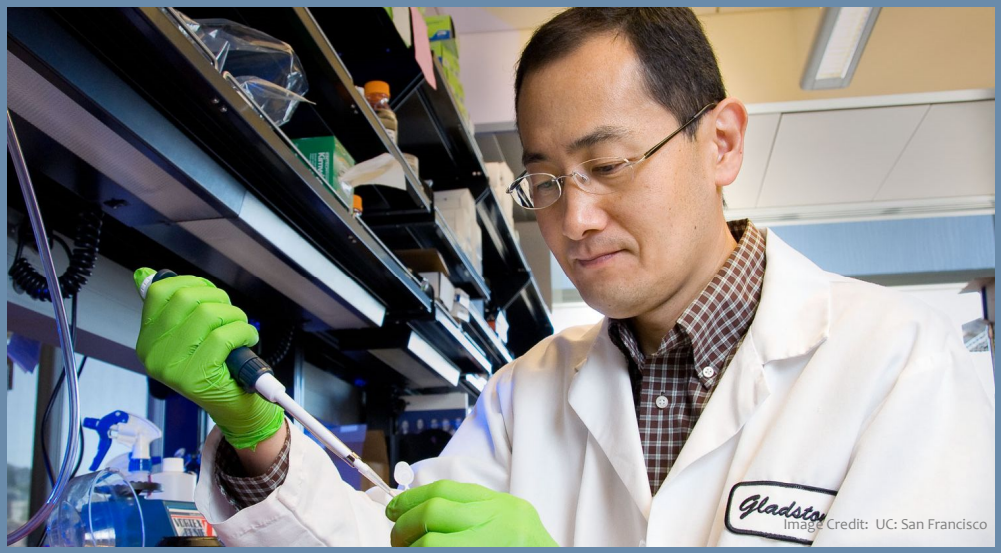


Image Credit: UC: San Francisco

Yamanka Revolutionises Science

Reporting by Ben Johnson, Elspeth Mackellar, Hollie Poulter & Chris Williams

Yesterday Dr Shinya Yamanaka was awarded the Nobel prize in medicine for his ground breaking stem cell research. Working at Kyoto University, he was able to convert specialised adult skin cells into unspecialised stem cells, work described as revolutionary by the Nobel committee.

The field of stem cell research began in the 1960s with scientists such as James Till and Ernest McCulloch at the University of Toronto. These two scientists discovered stem cells by injecting bone marrow cells into irradiated mice. Their work, along with that of John Gurdon of the University of Cambridge with whom Yamanaka shared the 2012 Nobel, inspired Yamanaka and facilitated his research.

The human body is made up of over 200 different types of cells, each with a specific function. Unlike these cells, a stem cell is unspecialised. The role of stem cells in the body is to develop into any specific cell type and to replicate to replace dead or damaged cells.
There are two types of stem cells; embryonic and adult. Embryonic stem cells come from a 3 to 5 day old embryo, and have the potential to develop into any cell. They can be isolated from embryos easily and grown in specific laboratory conditions. These cells replicate rapidly and their numbers increase quickly. Adult stem cells reside in the tissue of origin and are used in the body as an internal repair system. They are rare, which makes them difficult to identify and isolate for scientific purposes.

"My goals are to develop new drugs to treat intractable diseases by using iPS cell technology and to conduct clinical trials on patients with Parkinson's diseases, diabetes or blood diseases"
-Yamanaka 2012

Stem cells have a huge potential in the field of medicine. They are invaluable for the development of potential cures and treatments of life threatening disease such cancer, cystic fibrosis and Parkinson's disease. However there are issues. Embryonic stem cells can be rejected by the recipient's body, whereas adult stem cells from the patient would not. Unfortunately adult stem cells are harder to cultivate. There are also cultural issues as manipulating these cells can be seen as "playing God" and, with embryonic cells in particular, there is the issue of destroying a potential life.

To address these problems Yamanaka's field of research returns adult stem cells back to unspecialised stem cells, they are then known as Induced Pluripotent Stem Cells. He did this by inserting genes into skin cells using a virus, causing it to forget its function and return to an embryo-like state. These cells could potentially eliminate the need for embryonic stem cells and allow medical treatments to use cells from the patient's own body in a more efficient way. They can also be used for drug trials therefore removing the need for animal testing.

There have been some concerns about using stem cells in medical treatments as we do not know the long term effects on patients yet. However, with current advances and breakthroughs, such as the work by Yamanaka, there will hopefully be safe and useful stem cell treatment in all future areas of medicine. Δ

The Curious Case of the Mars Rover

Image Credit: NASA

Image Credit: NASA

On August 6th 2012, after a 9 month journey, the Curiosity Rover successfully landed in Gale Crater on Mars. Since then, the rover has been constantly sending data measured with it's various tools back to Earth. Alice Fickling, Bethan Frugtniet, Verity Hanson, Olivia Maguire & Vaneet Mehta find out more.

Curiosity is a car sized robotic mobile laboratory which carries 10 instruments capable of in depth analysis of the surface of Mars. Setting off from Cape Canaveral Air Force Station in Florida on November 26th 2011 and landing on Mars on August 6th 2012, the Curiosity Rover is the latest project from NASA's Mars Exploration Program which started in the 1960's and landed the first rover Sojourner in 1997.

The overall goal of the curiosity is to assess whether Gale Crater, a 155km wide bowl containing a mountain layered with sediment and minerals had, or still has, conditions suitable to preserve or support life. This is split into eight objectives covering biological, geological/geochemical, planetary evolution, and surface radiation. By looking for the key organic building blocks to life such as carbon and oxygen in Mars' atmosphere, and the geology and chemical composition of the Martian surface, NASA hopes to get closer to understanding Mars' environment and the biological processes which may have occurred there as well as gaining deeper understanding on the formation of the planet.

In order to achieve it's objectives, curiosity contains 10 different instruments and a total of 17 cameras. In addition to these, the rover has a 2.1m robotic arm, which is collapsible whilst the rover is driving between points of interest.

One of the 10 instruments on the Curiosity Rover is the radiation assessment detector (RAD) which measures the levels of radiation. This radiation is harmful to living organisms (from microbes to humans) and could potentially interact with a spacecraft, which raises safety concerns for the possibility of human exploration. The levels of radiation on Mars are higher than on Earth since its atmosphere is 1% as thick and doesn't have a worldwide magnetic field, which protects us here on Earth. By measuring radiation we can determine the levels that an astronaut would experience on the approach to and on the surface of the planet. It will also help to determine whether the Gale crater did or ever could sustain microbial life.

Curiosity's Dynamic Albedo of Neutrons (DAN) instrument has been used numerous times on the mission and is designed to check for hydrogen and water held in minerals to a depth of ~1m beneath the Rover. The discovery of such minerals could give a clue as to whether the planet was once able to support life.

One of the aims of the mission was to characterize the geology of Mars and look for evidence of rocks that may have formed in the presence of water. To do so, Curiosity has used tools called the Alpha Particle X-Ray Spectrometer (APXS) and the Chemistry and Camera (ChemCam) instrument to assess what chemical elements are in target rock to get an idea of the geology and chemical composition of the surface of the Red Planet. Curiosity has returned images of rocks made of gravels and sand at a site named 'Hottah' which suggest evidence of an ancient flowing stream. The large size and rounded shape of the rocks found indicate that they have been transported and eroded in water. Satellites have previously shown images of channels on the planet's surface that were thought to be formed by a flow of water but only due to Curiosity has evidence to support these observations been found. Due to the discovery of these rock formations it is thought that 'Hottah' is situated where a network of streams once flowed.

Curiosity may now be used to identify the composition of the rocks which would reveal the environment present when these features formed. Currently the Curiosity Rover is at a location termed 'Rocknest' where it will take a sample from the surface of Mars for on board analysis. The next step is for the Rover to then move to 'Glenelg' where it plans to use its drill and also to the base of Mount Sharp, which shows signs of being exposed to liquid water long ago. The Rover is expected to spend the rest of its journey carrying out observation and sampling activities from different areas to meet the goals set out for the mission.

Other than the Curiosity Rover mission, there are a lot of future plans for Mars Exploration, the most imminent being the Mars Atmosphere and Volatile EvolutioN (MAVEN), which is planned for 2013. It is the first mission devoted to understanding the Martian upper atmosphere and how the loss of atmospheric gas changed the Martian climate. The ExoMars project is also planned for 2016 onwards when an Orbiter and a Rover will study the atmosphere for gases which could indicate biological activity and rocks on the surface. There are talks about Human Exploration on Mars but safety is cause for concern.

Exploration and the resulting insights into conditions on Mars, like the investigation by the Curiosity Rover, may allow us to get one step closer to sending astronauts to the Red Planet. Δ

Are we losing the fight against Superbugs?

With antibiotic resistance on the rise, we ask how can we win this fight?

Reporting by Karla Giles, Matthew Lau, Richard Tattersall, Stephanie Whybrow & Kathryn Williams

Image Credit: The Gryphon

Before we start the discussion on antibiotic resistance, some definitions are in order. An antibiotic is a type of antimicrobial that is active against bacteria to either kill or prevent bacteria from growing. Superbugs are bacteria which have evolved features that allow them to be resistant to several types of antibiotics. This means that superbug bacterial infections are very difficult to combat and can therefore cause a lot of harm very quickly. Superbugs are contributing to the re-emergence of previously well controlled diseases such as TB. There are now nearly half a million cases of multidrug-resistance tuberculosis a year worldwide. Due to the serious risk caused by the emergence of these resistant strains, millions of pounds and a lot of time are being invested to try and find solutions to this problem.

There are several methods that have been proposed to try to stop these bacteria from 'winning the war'. Firstly, large companies such as Glaxo Smith Kline (GSK) are trying to synthesize new antibiotics to fight the superbugs. However, this has been proven to be very difficult as the structures of these antibiotics are complex and therefore challenging to understand and remodel.

So far 99% of our antibiotics are from natural sources such as soil fungi and microorganisms. Following this route, new research is taking people into unstudied areas in the search of new microbes that naturally produce antibiotics. On such location is the untouched caves of New Mexico. In these caves the environment is harsh and competitive with no light and few nutrients. When a bacterium is in this setting it produces antibiotics to defend itself from the competition. From one location, scientists were able to find at least one new antibiotic which is currently under tests for effectiveness on multidrug resistant bacteria, along with several other samples.

However, as they have for each previous 'new' antibiotic, the superbugs will eventually evolve to be immune to the new antibiotics. Scientists are therefore researching alternative treatments to antibiotics. An important mechanism that has arisen in this research is quorum sensing. Quorum sensing is a mechanism where signalling molecules are released from bacterial cells and recognised by specific receptors on both the bacterium that released the molecules and those surrounding it. When there are lots of bacteria they each receive a large concentration of the signalling molecule, causing changes to the behaviour of many cells simultaneously. Researchers have discovered that because bacteria are so small they need to work together in order to cause any harm to a large entity such as humans and quorum signalling is the mechanism they use to coordinate this. As a result, a theory has been proposed to block the bacteria from quorum signalling with an 'anti-quorum sensing molecule' and so prevent the bacteria from working together to cause harm.

The final defence proposed as an antibiotic alternative is to use the bacteria's natural competitor, the bacteriophage. Bacteriophages are viruses which only attack bacteria and are among the most common and diverse organisms on Earth. The virus attaches to a bacteria and then injects its own DNA into it. Once its DNA has been injected, the virus multiplies inside the bacterium until it has expanded too far and thus explodes, releasing the virus. The proposal is that scientists could develop bacteriophages to fight for humans against the superbugs.

Image Credit Shutterstock

Non-specific phage therapy can be dated back to the early 20th century, soon after their discovery, and these treatments have continued, particularly in the Soviet Union during the Cold War.

However, phage therapy as a modern treatment has encountered many barriers. The first is that specific bacteriophages attack specific bacteria so the therapy must be directly targeted to the patient's infection. Additionally, as with antibiotics, bacteria can evolve different receptors, making the phage ineffective. Finally, there are currently regulatory issues with phage therapy so there are no specific phage treatments currently authorised for use in the UK or US.

The threat of superbugs is still, and will remain, a concern for generations to come. Though there are many developments to try and eliminate specific superbugs, the main goal is not so much to win the war as it is to keep one step ahead of their ever evolving defences to win each individual battle. Δ

2012 Team GB: Cyclists or Sci-clists?

Image Credit: AFP

Reporting by Toni Ashford , Eloise Braun, Emma Browne, Maya Kolaska & Natalie Razavi

It has been widely documented that the application of cutting-edge science contributed to t he 2012 Olympic success of the GB track cycling team. Scientific knowledge is utilised to target multiple areas of elite cycling performance. Despite the fact that numerous aspects of the tear 's 'winning formula' remain undisclosed, information regarding the specific tailoring of diet, use of specialised materials and perfectly designed equipment is known.

Team GB cycling nutritionist, Nigel Mitchell, ensures that the most up-to-date scientific knowledge of nutrition is applied to the diets of athletes. An in depth understanding of the action of the five main food groups on the body is essential to maximise the effectiveness of training, racing performance and recovery. Cyclists follow a strict diet that incorporates particular food groups at certain times of the day and adjusts to meet the immediate physical requirements of the athlete. For example, during training the body mainly requires energy. Hours of cycling drains the body of energy and so it is fundamental that enough energy is provided from food. As a result, during training the athletes eat little and often and consume a variety of carbohydrate rich foods including sports 'gels'.

After completing a training session or race, efficient muscle recovery is essential and is maximised by intake of dietary protein. Muscle protein is broken down during training and races and hence sources of protein are consumed to restore optimum muscle protein levels. Team GB elite cyclists consume protein rich sports drinks immediately after a race to ensure fast recovery – hence maximising performance in the next race. Knowledge of the importance of hydration results in cyclists consuming large quantities of water at multiple times of the day.

As one would expect, a perfect 'race bike' design is essential for success. It is imperative that the bike is strong but also is low in weight. As a result, components of the bike, including the frame, are made from a synthetic carbon fibre material which gives the design strength but is also low in density so ensures that the bike is lightweight. Additionally, track bikes are made to be able to withstand relatively high pressures by using silk tyres. Due to an increased molecular-level understanding of materials it is possible to select those that are best suited to enhance the bike design. As a result, advances in this field of science have enabled the creation of the 'perfect' track bike.

Synthetic material technology has also enabled the development of perfectly designed Lycra suits and also 'heat suits' that athletes wear after warming up until the start of a race to keep their muscles warm. These 'ADIPOWER' self-heating shorts contain heated strips to maintain an optimum temperature of 38 °C, which has been found to provide a significant increase in sprinting power — essential to win a race.

Air-pressure drag is one factor that is minimised as much as possible. Training conducted in wind tunnels has enabled the design of a bike that is optimally aerodynamic, hence drag has a reduced impact on the race. Furthermore, the shape of helmets is as streamlined as possible. The helmets also incorporate a 'honeycomb' of aluminium, which can effectively absorb impact should the rider crash. Rider position is also carefully considered to ensure that the cyclist is also streamlined, hence performance is maximised. In addition, recent studies have investigated a link between genetic information and increased athletic performance. As a result, there is a theory that the cyclists were born with a 'superhuman' DNA combination. To date, over 200 human genes have been linked to athletic excellence, including those responsible for energy production, muscle development and endurance. As a result, it has been suggested that the achievement of elite sports people is due to the fact that they were born with a perfect combination of these genes. However, it seems very unlikely that inherited DNA is solely responsible for sporting success. Instead, it is most likely that numerous factors contribute to world class performances such as those of 2012, including the hours of intense training and application of modern science. There is no denying that team GB cyclists are naturally physically and mentally well suited to elite competition, but it seems improbable that this factor alone results in their success.

The scientific field is one that is rapidly advancing, so it is inevitable that, in the future, scientific discoveries will be used increasingly to enhance elite GB track cycling. The field of cycling still has some speeding up to do. Δ

The future of Regenerative Medicine

It may soon be possible to replace our body parts when they wear out or are afflicted with disease or injury. With the first successful transfer into humans of bladder replacements grow in a laboratory setting, Andy Frain, Tom Miller, Harriet Shaw, Aaron Talma & Rachel Taylor investigate.

20% of the readers of this article will get to celebrate 100th their birthday! Sound good? Not really! As we grow old our bodies deteriorate. The growing elderly population already costs society millions in lost productivity and NHS care. Furthermore, with 3 people dying a day because they cannot get an organ transplant, and further complications caused by rejections there seem to be few solutions. Regenerative medicine is one possible solution which involves revolutionary techniques, whereby tissues are repaired and replaced using the body's own cells, eliminating the need for donors. Regenerative research isn't a phenomenon that 'might happen' in the distant future. It is in fact being used today to grow a viable bladder.

Here we look at the innovative and rapidly advancing field called tissue engineering and its application to the bladder. Regenerating neo-organs such as the bladder combats both the problem of organ rejection by the recipient and the huge deficit in organ donors across the world. Deservedly at the forefront of this field is Dr Anthony Atala who pioneered the world's first lab-grown bladder. At the cutting edge of organ engineering is Tengion – a biotech company whose most successful re-search to date has led to the creation of the Neo-Bladder.

The method for growing the organ is complex. Firstly, a bladder scaffold is made out of bio-material. 3D printers can be used to create this scaffold which can be designed to suit the patient. A small piece of bladder is taken from the patient (the size of half a postage stamp) and is teased apart into muscle cells and specialized bladder cells. These cells are grown outside the body into large quantities. The inside of the scaffold is coated with bladder lining cells and the outside with muscle cells. These cells are grown in an oven mimicking human body conditions.

Within 6-8 weeks this organ can be transplanted without the need to suppress the patient's immune system, as it carries no risk of rejection. Once the organ is in place the scaffold degrades and the bladder adapts to its home. This incredible science has already been confirmed as safe and effective, capable of treating the bladder effects of Spina Bifida. The future holds the prospect of making the neo-bladder more commercially available.

Image Credit: AB

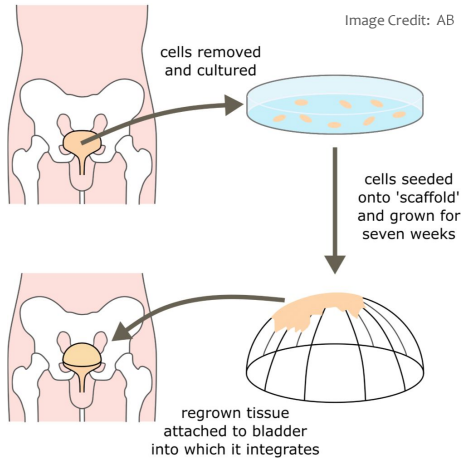


Image Credit: Urology Today

Building a solid organ like a liver in the lab is different and harder than an organ like the bladder because solid organs are very vascular—Anthony Atala

The next step in regenerative medicine is to replace more complex organs such as the kidney or liver. The structure of these organs is much more complex than in the case of the bladder so other methods have been tested to obtain a scaffold. One of these methods takes a cadaveric kidney and washes away all of its cells, leaving the vascular structure as a scaffold. This can then be seeded by the patient's cells. Due to the variability of cell types in a complex organ such as the kidney this method still has its issues, however, it has been successfully used in rats to create functioning kidneys which worked in vivo, albeit at a low proficiency. This could eventually lead to much better ways to treat renal failure.

Even though these techniques are ground breaking there are a few issues that need consideration. Something that is unique concerning regenerative research is that it typically requires creating individual therapies for each patient. Therefore, information concluded from one patient isn't as transferable to the next patients in later trials, whereas usually the information from the first trial can be used to design the next trial, making it safer for the patients.

With overpopulation already becoming an issue a longer lifespan will have a massive impact on society and politics such as national healthcare systems, retirement schemes and the working force. Modelling will be important in predicting the social and medical consequences of life ex-tension but no model is yet to forecast accurately.

Despite the obvious ethical implications and medical difficulties involved, it is impossible to deny the great leap forward in biotechnical medicine that these techniques hold. Their ability to reduce the suffering of thousands of people with chronic diseases is potentially far reaching and revolutionary. Δ

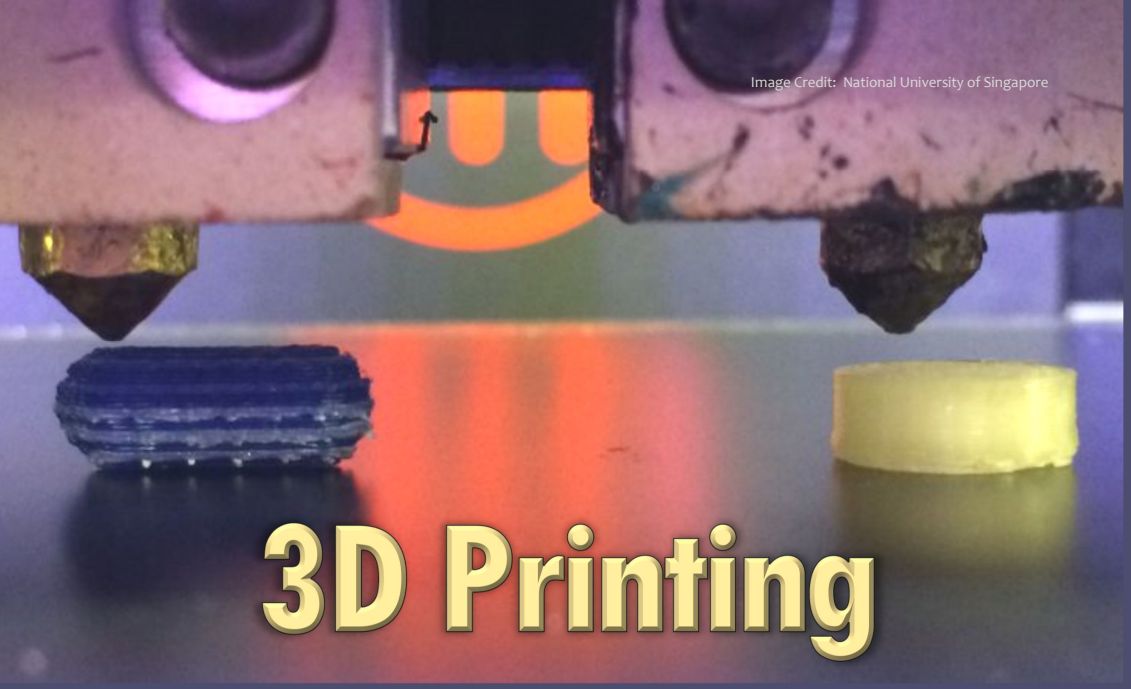


Image Credit: National University of Singapore

3D Printing Pharmaceuticals

With 3D printing moving more and more mainstream, the potential is moving beyond solid plastic or metal objects and onto pharmaceuticals. Could the pharmacies of the future be small desktop printers?

Reporting by Abigail Browning, Thomas Letchford, Owen Letts, Ian Saunders & Imran Ali Shafi.

The concept of 3D printing has been around for decades but it was not until the 1980s that it was taken seriously. Since then, there has been a revolution in computing power, making 3D printing a truly viable option for both commercial and domestic use. It is now used for a wide range of manufacturing: clothing, joint replacements and personalised products. The next frontier is arriving – a desktop drug factory.

In May 2012, Lee Cronin of the University of Glasgow published a paper describing the future of drug production. He took a low-cost, standard 3D printer and converted it into a robotic chemist by building reaction chambers and injecting different chemical ingredients. His method initiates chemical reactions by printing the reagents directly into a 3D 'reactionware matrix'. Reactionware, Cronin says, is 'the concept of the glassware and chemicals together in a 3D printer' and that 'In the future, we will not sell drugs, but blueprints or apps'.

With this new technology, you would no longer need to collect your drugs from a pharmacist. It would be possible to simply download a blueprint for your desired drug and use the software and a chemical 'ink' with your home 3D printer to print the drugs at home. This technology could also allow individuals to have access to a range of chemicals without an expensive laboratory, as they could simply 'print' out the chemicals they require. This could lead to many more chemical discoveries as the chemical sciences became more accessible in developing countries.

Drug production in this manner has not yet been achieved. The current technology works by first constructing the reaction chamber using a standard Fab@Home printer and Loctite – a bathroom sealant. The equipment is initially constructed, sealed and the reactants are added later to the relevant chambers. Vacuum needles then suck the reactants through. Depending on the rate of reagent addition, the size and shape of the reaction chamber, different complex chemical products can be formed. At the moment this process is able to complete various organic and inorganic syntheses and in situ spectroelectrochemistry – the combination of electrochemical and spectroscopic analytical methods.

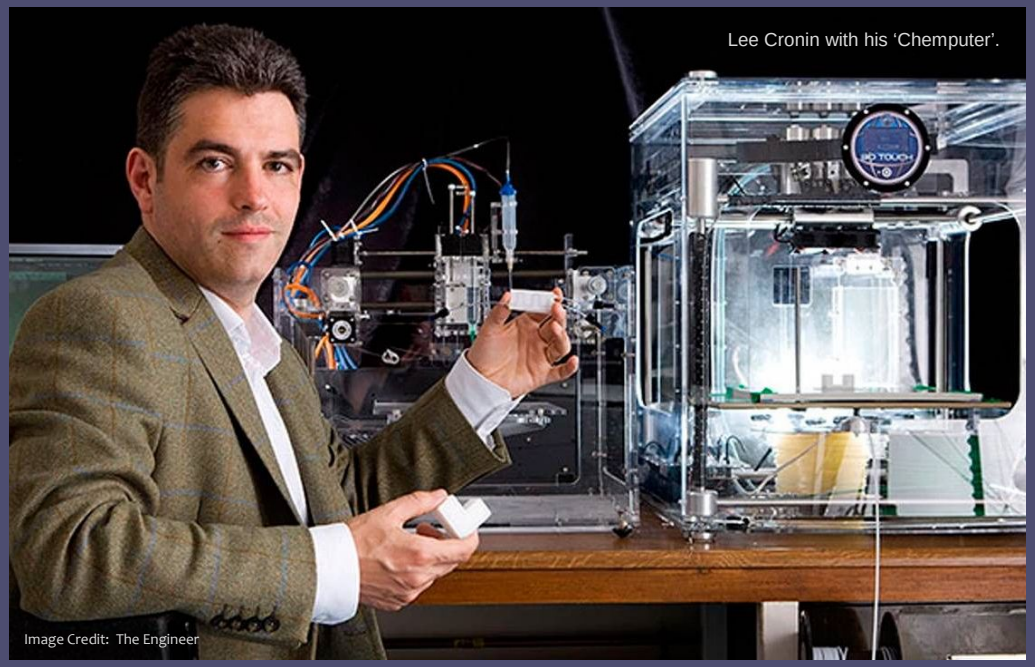
The benefits of this new technology are enormous. Greater distribution at lower cost could revolutionise drug availability, especially in developing countries where medicines are not easily accessible due to geographical or economic restrictions. By taking power away from big pharmaceutical companies, it could potentially enable a larger range of drugs to be made for small demand or less economically viable markets. Another possible benefit is tailored drugs to the individual's need; dosages, chemical composition allergies and other concerns could be adjusted to the individual.

> 'In the future, we will not sell drugs, but blueprints or apps'
>
> Lee Cronin

As with standard 3D printing there are some major issues to overcome. Though there is the idea of restricting drug production by providing people with one-use-only prescription blueprints for the reactionware, there would always be the potential for hacking the equipment to produce large amounts of the prescribed substance. There is also a potential for criminals to share 'recipes' for illegal substances. This could make the illegal drug market larger and also create more of a problem of so-called 'legal highs'– slightly altered versions of illegal drugs like MDMA that have similar effects on the body.

Up until now the machine has used bathroom sealant to create the reaction vessels so the products have not been fit for human consumption. Cronin's next step will be to replicate the drugs already available in pharmacies in a way that makes them safe for use. The printer's speed and precision is another improvement they have set their sights on.

As Cronin has noted, "we are still quite a way off from all having a drug factory in our bedrooms"; he predicts a time frame of 10 to 15 years for this technology to become mainstream. Perhaps by then solutions to some of the additional issues will have been found. For now at least, we will have to make do with traditional chemistry labs and the production stranglehold of drug companies. Δ

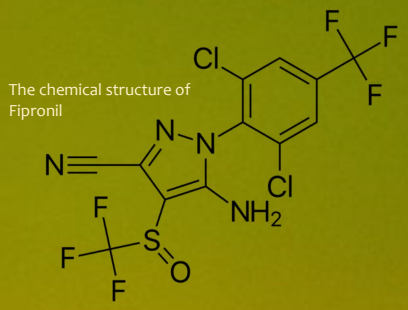


Lee Cronin with his 'Chemputer'.

Image Credit: The Engineer

Image Credit: BBC

Can EU ban save the Honeybees?



The chemical structure of Fipronil

Reporting by Matic Hribersek, Rachel Hsuan, Jemma Hughes, Rosie Leeson & Ellie Rose

The world's ecology and economy relies on successful protection of honeybee populations Honeybees are vital to both the world's ecology, and economy. One third of our diet relies on insect-pollinated plants, 80% of which depend on the honeybee. This pollination contributes €22 billion per year to Europe's agriculture alone.

But in the last decade, a decline in the world's bee population has become a serious cause for concern. The British Beekeepers Association has been monitoring colony losses over the past six years, and the latest results show that the decline is at its worst. In the last year alone, there has been a 34% decrease in the number of European honeybees (apis mellifera) compared to only 16% in 2012.

On July 16th this year, the EU issued a 2 year ban (to be enforced from 31st December 2013) on the popular insecticide fipronil, in connection with its suggested role in the disappearance of honey bees. This mysterious phenomenon, known as colony collapse disorder (CCD), occurs when the worker bees of a hive abruptly vanish. Other symptoms include no trace of dead worker bees in the vicinity of the hive and once uninhabited, delayed invasion by other pests. So what exactly is causing so many hives to be left empty? The exact reason for CCD is unclear, with suggestions including the influence of parasitic Varroa mites, viruses and habitat loss. However, pesticides in particular have come under scrutiny for their adverse effects on honeybee populations.

Current focus is on neonicotinoids, a group of pesticides in which fipronil is included. Fipronil was discovered and developed by Rhone-Poulenc between 1985 and 1987, it is part of a family of chemicals called phenylpyrazoles. It was initially developed as a pesticide for agricultural and household use, and became commercially available in the US in 1993. It remains the active ingredient in the majority of flea and parasite treatments for domestic animals.

Fipronil acts by disrupting the central nervous system which leads to hyperexcitability and death in its target. While there are already regulations in place to prevent bees receiving lethal doses of fipronil, chronic exposure to low levels of this pesticide, although not deadly, are still harmful to the colony.

Honeybees use the scent of different flowers to create an olfactory map, which they then use to navigate when foraging and collecting nectar. In sub-lethal doses, fipronil has been shown to impair honeybee's learning ability and memory, which is necessary for accurate homing. This was demonstrated in one study when 10% of foraging worker bees did not return to the hive, following ingestion of small amounts (0.5ng) of pesticide. A computer model based on this data predicted that 67% of a colony would die under these conditions.

Many argue that the two year ban does not afford a sufficient time frame to measure the effects on bee population trends. Although this ban is step in the right direction to protect Europe's honey bee population many more factors need to be considered in order to ensure that the current decline does not continue. Δ

The Stellar Nuclear Future

The hunt for clean energy has passed a new milestone at the National Ignition Facility in California. Could this 'break-even' point give new life to nuclear energy?

Image Credit: Lawrence Livermore Laboratory

Reporting by Humairaa Al-Haddad, Sarah-Anne Bee, Rosalie Cresswell, Conor Haselden, Luke Jones & Peter Ryan

An important breakthrough in the development of nuclear fusion has been made this week by researchers at the National Ignition Facility (NIF) in California. The fusion reactions carried out there are believed to have passed the so-called "break-even" point, where the amount of energy produced by the reaction equals the energy consumed by the fuel. Surpassing this point is a major milestone on the way to finding a fusion process that is a self-sufficient, feasible way of providing energy.

For fusion to occur, light nuclei must be forced close enough together for the attractive nuclear force between protons and neutrons to overcome the electrostatic repulsion between protons. The required separation between nuclei is miniscule and is only possible during high speed collisions. The NIF concentrates the most powerful laser in the world – which uses 192 separate beams to create a 500 terawatt burst of light – onto a single spherical pellet of deuterium and tritium fuel weighing just milligrams. The extreme temperature and pressure convert the surface of the pellet into plasma, which then explodes violently outwards from the surface. These conditions mimic those at the heart of a star, where fusion occurs. As a consequence there is recoil from the explosion, sending a shockwave inwards as the fuel collapses, causing its volume to decrease rapidly. Finally, the density reaches a level – several hundred times that of lead – that is sufficient for the necessary high-speed collisions to occur and nuclear fusion to take place. A crucial step follows where highly energetic alpha particles are produced by the fusion reaction. The density of the fuel is now so great that the particles immediately convert their energy to heat via collisions. Ideally, this extra heat fuels additional fusion and a chain reaction is initiated. This is known as the "ignition point", where energy is produced at a rate sufficient to drive the reaction without further energy input. Unfortunately, experiments so far have only managed to transfer less than 20% of the laser's energy to the fuel, meaning the reaction cannot yet proceed to this crucial point. Scientists hope that when this ignition point can be consistently reached, nuclear fusion will become a realistic prospect for large-scale energy production. The potential benefits of achieving this would be globally significant. The fuel, mainly consisting of deuterium, can be considered a renewable energy source due to its abundance on Earth and its attractive high energy to weight ratio.

Another appealing property of nuclear fusion is its lack of undesirable by-products; no greenhouse gases or long-term radioactive waste are produced as a result. With this new achievement at the NIF, nuclear fusion may be increasingly seen as a promising solution to the planet's increasing demand for energy and chronic dependence on an ever diminishing supply of fossil fuels.

However, even the most optimistic predictions have 2050 as the earliest starting point for energy produced by nuclear fusion to be commercially available on a significant scale. With this in mind, the breakthroughs this week in California must be seen as one small step on a long road, giving the world new hope in the potential of nuclear fusion. Δ

Type 2 Diabetes

Reporting by Samuel Allen, Lois Grimshaw, Dominic Mistry, Thomas Morgan and Christian Rubin

Image Credit: Medical News Today

With the incidence of diabetes on the rise and more than five million people expected to be affected by 2025, our reporters give us the facts of the disease.

Diabetes is a chronic condition in which the body can't regulate blood glucose. This leads to high blood glucose levels, which are harmful to the body causing serious, sometimes fatal, effects. Blood glucose levels are lowered by insulin, a hormone produced in the pancreas that allows glucose into the cells as fuel for energy. There are two types of diabetes; type 1 occurs when the pancreas can't produce insulin, but in type 2, insulin is at low levels or cannot be used effectively by the body. Worldwide, over 250 million people suffer from diabetes and approximately 90% of those cases are type 2. Current studies suggest that the number of diabetics will only continue to rise in years to come.

Type 2 diabetes can be caused by a combination of lifestyle and genetic factors. Some of these are preventable, whilst others are out of your control. Obesity or having excess body weight (particularly around the waist) is a major risk factor. This generally results from a lack of exercise and a poor diet high in cholesterol, sugar and fat. It is believed that obesity directly causes a reduction in responsiveness to the effects of insulin. Other factors that are out of your control and may put you at a higher risk include; a family history of the disease, being of Afro-Caribbean or South-Asian origin, and being over the age of 45. Some drugs and diseases can also put you at risk, as can pregnancy.

The symptoms of type 2 diabetes result from a consistently high levels of glucose in the blood. However sometimes these symptoms aren't always obvious and some individuals can have the disease for several years before diagnosis. Sufferers often feel tired, thirsty and hungry, due to the inability of glucose to enter cells and be used as energy. As a result body fat is used for energy which can then lead to weight loss. The body tries to combat these high blood glucose levels by removing excess glucose in the urine. The presence of extra glucose in the kidneys produces a higher volume of urine, that when removed from the body causes increased thirst and dehydration, and also blurred vision. Long-term complications include; kidney damage, heart and circulatory problems, slow-healing wounds, high frequency of infections, damage to the nervous system and blindness.

Currently there is no cure for diabetes, however, there are a variety of treatments available to manage it successfully. Type 2 diabetes is initially treated by weight loss through a controlled sugar-free diet and regular exercise. If blood glucose levels remain high, drugs in the form of glucose-lowering tablets, such as Metformin or Gliclazide, can be prescribed. These drugs work to help reduce blood glucose by increasing the sensitivity of cells to insulin, decreasing the amount of glucose released from the liver and increasing the insulin released from the Pancreas. Sometimes if blood glucose levels are not well controlled through glucose-lowering tablets, individuals may be advised to take supplementary insulin injections. Additional treatments aim to reduce absorption of glucose by the intestine, thereby preventing glucose from entering the bloodstream and helping to break it down. In some more extreme cases, weight loss surgery may be required.

Diabetes can lead to complications in many parts of the body and increase the risk of dying prematurely.

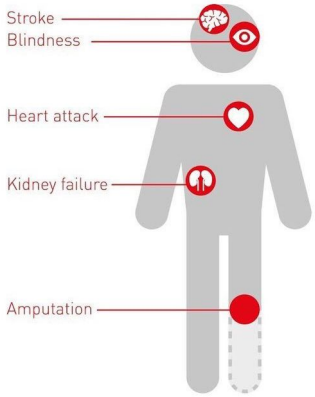


Image Credit: WHO

Research into cures and medication for type 2 diabetes has been ongoing for many years. Drug development is a slow and costly process, and due to extensive testing it can take up to 10 years to bring a new drug to market. Much of this research is done by large pharmaceutical companies that can afford to run clinical trials. Additionally there are several research networks such as National Institute for Health Research Diabetes Research Network that was set up in the UK in 2005. Their work helps to understand the risk factors and develop new ways to treat and prevent the disease. Other areas of leading research come in the form of nanotechnology where tiny insulin implants could monitor and regulate insulin to blood glucose levels when required. A recent study into the composition of blood has identified 14 key metabolites that are linked to diabetes. These metabolites could act as markers to identify individuals who are at a higher risk of developing diabetes, and may also give further insight into the biological pathways. Δ

Image Credit: WHO

Image Credit: Energy Central

Methane Hydrate

Do recently discovered deposits of frozen natural gas have the potential to revolutionise the global market?

Reporting by Jon Marsh, James Peake, Katie Pollard, Emma Povey & Ian Roper

Trapped deep beneath the ocean floor lie icy reserves of untapped natural gas; vast energy stores begging to be harnessed. Methane, captured in frozen watery cages, is waiting in such quantities that could dwarf current supplies of coal, oil and natural gas. As a plentiful and potentially 'greener' fossil fuel than coal or oil, energy-starved nations and environmentalists alike are desperate to access this new source of energy.

The material of interest is methane hydrate, which has a very unusual structure, called a clathrate. This is formed when methane molecules, excreted by microbes feeding on organic matter, are locked into a cage of water molecules and trapped in the sediment. This process requires low temperatures and high pressures, and so most methane hydrate reserves are located at water depths of over 1000m. Large deposits have recently been located in the Arctic permafrost, on the ocean floor and in sediments hundreds of metres below.

What is so exciting about these deposits is their abundance — the US Department of Energy estimate there to be 700,000 trillion cubic feet of methane stored in hydrates; a staggering volume which would provide twice the energy of the world's current fossil fuel reserves combined. In addition, methane releases less CO_2, less ash and less mercury when processed and burned than coal and oil. Also, if using local reserves, it could be cheaper and cleaner than importing natural gas.

However, this source of methane is by no means a silver bullet; locating the gas is a lengthy process which requires seismic imaging, and extraction in deep water marine environments can be problematic. Specialised equipment is necessary as methane expands to up to 160 times its initial volume during its journey to the surface. There are other drawbacks, for instance, despite their vast volume, most methane reserves are found in low concentrations and low quality deposits, making them a less economically viable energy source.

Despite the many difficulties surrounding the extraction of methane from hydrate reserves, promising developments have been made. Leading the field of research, the Japan Oil, Gas and Metal National Corporation (JOGMEC) successfully extracted gas from methane hydrates off shore earlier this year, a world first. This test period produced around 20,000 cubic metres per day, reaching a total of 120,000 cubic metres, and will be followed by a production test in 2014. This is of great significance for Japan, a nation largely dependent upon foreign imports.

Tapping into these methane hydrate reserves could waylay fears currently held about the gas leaking into our environment. There are substantial concerns about the effects an uncontrolled release of methane could have on the atmosphere, due to the gas' high global -warming potential. Using these deposits as a fuel source could potentially eliminate this risk. However, some studies suggest the hydrates will remain stable, even with rising sea temperatures. The impact of commercial scale

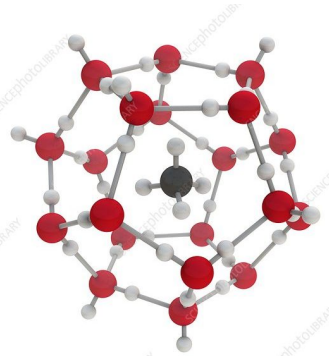


Image Credit: Science Photo Library

extraction on the local environment also has to be considered - sulphide molecules associated with these methane reserves provide an energy source for chemosynthetic bacteria. These bacteria are the foundation of photosynthesis-free food chains, essential for deep water ecosystems.

So is this the answer to the finite fuel puzzle the world is furiously trying to solve? Unfortunately not. Even if extraction is perfected, the amount of methane hydrate beneath the seabed is finite and will eventually run out. It may, however, buy us time to come up with a sustainable solution to solve this conundrum for good. Δ

Looking forward…

Everyone is talking about greenhouse gases, global warming and ever-rising sea temperatures, and the increasing level of carbon dioxide plays a significant part in this worry. A new answer to these concerns may be found through research currently being carried out by the US Department of Energy and JOGMEC in an attempt to commercialise a carbon neutral extraction method. This method is based on the ability of carbon dioxide to initiate the release of methane from its clathrate by offering itself as a substitute. Subsequently, in one step, it may be possible to extract methane and sequester the most problematic greenhouse gas. However, this promising research is still in its infancy and nothing is for certain, so the worriers will still have to worry.

Image Credit: ChemBites.org

Staying in Touch

Reporting by Liam Donaghy, Timothy Fogarty, Sophie Jones, Joanna Knight, Helen LaPiccirella & Matthew Whitehill.

As touchscreen devices have cemented themselves into our everyday lives, they have made our interactions with technology more intuitive. But what exactly is going on beneath our fingertips?

Perhaps the most common touchscreen you may encounter — be it in a cash machine, a games console, or in signing for a parcel — uses pressure response to track your touch. These resistive touchscreens consist of two separated layers of conductive material. When pressure is applied, either by finger or stylus, the two layers make contact causing a change in the electric field. This in turn induces a change in the resistance of the circuit, which is measured by the computer. These resistive touch screens are favoured for some applications due to their resilience to fluid damage and are generally cheaper to produce than other popular technologies. Hardy and cheap they may be, but internal reflections between layers impact the contrast and they are also susceptible to damage by sharp objects.

The technology used in the latest smartphones and tablets is capacitive. These touchscreens were originally developed before resistive touchscreens but the latter quickly became the dominant technology due to their price and toughness. The trend was reversed with the development of multi-touch technology in capacitive screens. These screens are made up of glass and a thin transparent layer storing electrical charge. Since the human body can conduct electricity, when the screen is touched, the charge transfers to the user. This decrease in charge is measured by circuits in the corners of the screen, pinpointing the location of the touch. Capacitive touchscreens have a brighter display due to fewer internal reflections. However, their reliance on the natural conductivity of the human body means you'll have a hard time trying to use one with gloves!

The primary material used for the transparent conductive layer is indium tin oxide (ITO). This is a solid solution of indium (III) oxide (In_2O_3) and tin (IV) oxide (SnO_2) typically at a ratio of 9:1. China is the biggest supplier of indium but, as the demand for touch screens steadily increases, the supply of ITO cannot keep up. Experts suggest it could run out by 2017, sparking a race to develop new technology.

A viable alternative to ITO, called 'GraphExeter', has been developed by The University of Exeter. Two layers of graphene provide a lightweight, transparent and conductive base material. Sandwiched between them is a layer of ferric chloride, enhancing the conductivity without hindering the transparency. The final product could replace ITO, and could even be used for flexible touchscreens since it is much thinner than current technology.

While the computing industry considers the implication of this research, a spray on version is also being developed, revealing possibilities for touchscreens so thin and flexible that they are wearable. The University of Pennsylvania are also hoping to ease our dependence on ITO with their developments of nanotube touchscreens. They are using computers to simulate different arrangements of nanowires to discover the optimum properties required. Further study hopes to provide possible deposition methods, leading to their eventual use in flexible touchscreens.

It is clear that huge advancements have been made since the concept behind touchscreens was first developed in the 1960's. An increase in demand for cheap, interactive, and flexible technology is driving the industry forward, ensuring touchscreens will become more sustainable and will play an increasing role in our everyday lives. Δ

Image Credit: Wallpaperplay.com

Behind the Meth

Reporting by Caroline Armstrong, Jedd Bellamy-Carter, Eleanor Cooke, Phoebe Cunningham & Joe Verity-Legg

The media is reporting an increase in use and awareness of the drug has risen thanks to an influential TV show, but what does methamphetamine really do to the body?

Methamphetamine (MA) is a class A illegal drug that is a member of a psychoactive group of drugs called amphetamines. Its chemical structure differs to that of amphetamine by the addition of a methyl group (CH_3); this affords MA greater solubility in fats allowing it to penetrate the blood-brain barrier more effectively than other amphetamines. There are two forms of MA (termed d and l 'enantiomers'). It is the d enantiomer that is illegal; the other is sold over the counter as a nasal decongestant owing to its far less potent psycho-stimulation.

The drug affects the body by stimulating mechanisms in the brain that alter levels of dopamine. MA causes a variety of neurological transporters, which normally take dopamine back to the neuron from the synapse, to reverse their action resulting in a surge of dopamine into the synaptic cleft. MA prevents dopamine uptake and degradation, causing prolonged presence of the neurotransmitter in the synapse and continual stimulation. This increased dopamine level is responsible for feelings of euphoria and increased self-esteem, however, such high concentrations can have detrimental effects on the brain. Although large quantities (30-54% of an oral dose) of MA are excreted unmetabolised by the kidneys, the rest is broken down by enzymes in the liver. These enzymes can exist in several forms based on genetic composition. Interestingly, individuals with a less active form of the enzyme are less able to metabolise MA, leaving an increased vulnerability to toxicity by build up of the drug but a degree of protection against dependence. Consumption of alcohol during use can also create this effect as alcohol is a depressant on the systems MA stimulates.

Addiction to MA can be characterised as a compulsive need for the drug leading to regular abuse. This is driven by the severe depression and crash experienced due to sleep deprivation and decreasing levels of dopamine when the drug wears off. Continual use of MA causes an adaptive decrease in dopamine receptors, resulting in the need for higher or more frequent dosage. After years of abstinence from MA, the number of dopamine receptors often increases to a normal level; however, the damaged dopaminergic pathways can lead to long term cognitive effects including symptoms similar to that of Parkinson's disease. There are also several external effects, like weight loss and tooth decay, referred to as 'meth mouth'. If taken while pregnant, the baby to be born with birth defects and tremors and an increased risk of lower birth weight and preterm birth.

MA's reputation arises from the abuse of the drug, however this is not the only way the drug is used. As a consequence of taking MA the body experiences euphoria, but it also feels increased alertness, increased energy levels and suppression of appetite, for these reasons it can also be used medicinally. Sold under the name Desoxyn, MA can be used to treat ADHD, exogenous obesity and in special cases narcolepsy and treatment resistant depression. The treatment course is rarely prescribed and only ever for a maximum of 6 weeks, due to the likelihood of subsequent drug dependency.

MA has had a large amount of media attention, making the public extremely aware of the recreational use of the drug. However there is more to MA than has been frequently portrayed, and it would seem pertinent that the media make evident to the public the scientific facts and medical understanding behind the use of the narcotic. Δ

Rocketing temperatures. Unstoppable melting. Species extinction. Is this the unchangeable future for our planet? Freddie Hale, Frances Hamilton, Yvette Harvey-Brown, Andrew Law, Rebecca Rene, Nabila Shaikh summarise the IPCC preliminary report.

The Intergovernmental Panel on Climate Change (IPCC) recently released their fifth preliminary report, summarising recent models and predictions regarding the future of the planet. In the respective press release the IPCC boldly stated, "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-twentieth century." As a result one of the most topical issues related to the Earth's warming is the disappearance of summer Artic sea ice.

So what does this mean for the future? In the last six years the annual loss of sea ice between summer and winter exceeded 10 million km^2; this has only happened once before 2007. The rising summer melt is not just an indicator of climatic change—the increase has considerable impact on ocean circulation, ocean productivity and regional climate. Shrinkage of sea ice will also amplify greenhouse effects through positive feedback mechanisms. From a biodiversity point of view, the rapid decline of summer Arctic sea ice will devastate polar ecosystems. Arctic oil reserves will become more accessible thus exacerbating carbon emissions.

To model the future of our planet, the IPCC have used a series of scenarios which take into account; the level of mitigation schemes for climate change, global population growth and rates of economic development which lead to alternative outcomes by the year 2100. The worst case scenario (Case A), doesn't factor in any targets to reduce climate change thus culminating in a 94% reduction in summer Arctic sea ice by 2100. Here the population is allowed to increase to 12 billion whilst technological development can't keep up with world demands. As a result, coal is heavily relied upon, there are numerous food shortages and high greenhouse gas emissions.

On the other hand, if we make a decent attempt at managing climate change and greenhouse gas emissions, then the best achievable scenario (Case B), would stabilise the level of CO_2 in the atmosphere by the year 2080. This means that we could realistically prevent the summer Arctic sea ice from completely disappearing with a reduction of only 43% by 2100.

The debate on whether sea ice loss is reversible relies heavily on whether we are able to reduce carbon emissions in the near future. In the meantime, it is accepted that September sea ice will have reduced dramatically by the mid-century and there is not much we can do to prevent this. Even if we stabilise greenhouse gas levels, we would still exhibit an increase in global mean temperature due to the cumulative greenhouse effect and sustained presence of CO_2 in the atmosphere. Realistically we have to expect further decline and disappearance of Arctic sea ice, but we can reduce the extent of this loss through a globally recognised strategy.

By mid-2014 the second contribution towards the IPCC report will be released. This will ideally lead to the implementation of key global policies for sectors including energy supply, agriculture and waste. It is too late to see a difference in our lifetime but the changes we make now are crucial to stabilise the rate of summer Arctic ice reduction. Δ

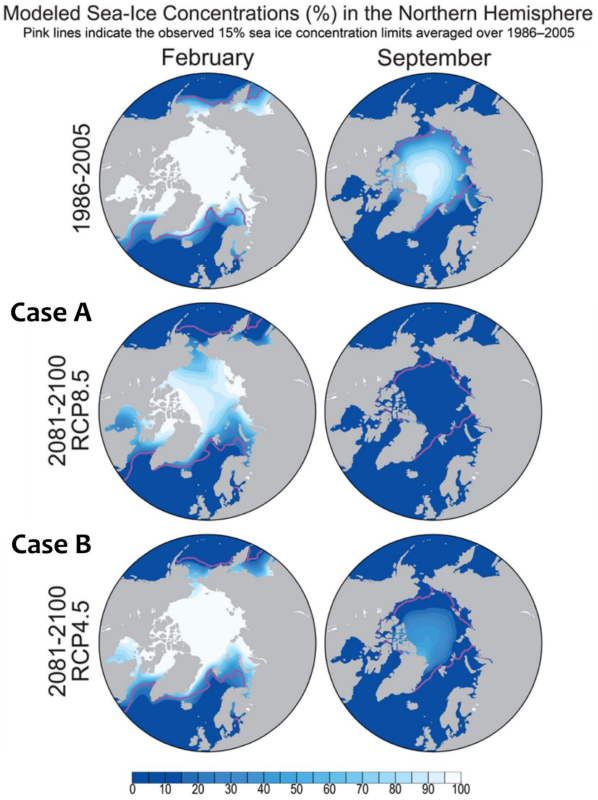
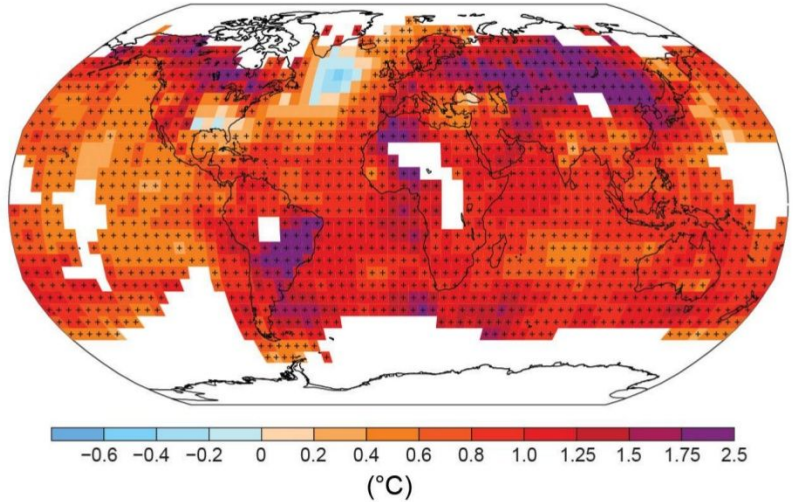


Image Credit above and below: IPCC 2013 Report



Observed change in surface temperature 1901-2012