Superbugs?... Superbad?

Image Credit: Lightsource Deposit Photos

Superbugs are set to cause 10 million deaths by 2050—more than cancer. But how did we end up here and is there any way back? Zoe Middleton, Christopher Ryder, Lucy Sayers, Adam Simm, Cameron Tero and Hannah Tofts Investigate.

The near future holds a world where infections will go untreated and cancer treatment, transplants and complex surgery will be impossible. The culprit: Antimicrobial Resistance (AMR).

But what is AMR? In bacterial populations some individuals are resistant to the effects of drugs due to a chance mutation; these bacteria will survive and multiply even when treated with antimicrobials. These resistant genes spread quickly in populations because of bacteria's ability to transfer genes via plasmids to other bacteria in the same generation. One such superbug is methicillin-resistant *Staphylococcus aureus* (MRSA); it can overwhelm the immune system and cause life-threatening infections such as blood poisoning. MRSA causes 11,300 deaths in the USA per year and this is set to increase rapidly in the future if new antibiotics or alternatives are not found.

Worryingly, despite resistance becoming a greater threat, no new antibiotics have been discovered in the last 40 years. However, there is some hope with the discovery of a new type of antibiotic, Teixobactin, in 2016. Currently in clinical trials, it is thought that bacteria will find this antibiotic more difficult to develop a resistance to than those in use now. The drug is the first to be discovered by screening microbes which do not grow in a lab, offering the promise of many more new antibiotics.

It seems, much like cancer treatment, there is no 'one' solution, but rather many specific treatments that need to be explored; some are preventative and some work to treat microbes post-infection. The importance of vaccinations in eliminate the need for antibiotic treatment by preventing infection from occurring cannot be overstated. Studies have shown that 'natural' antimicrobials can inhibit MRSA, and the use of viruses to attack bacteria in phage therapy has been successful. Alternative treatments are also on the rise: those suffering from enterocolitis, an infection of the gut caused by MRSA, can receive a faecal transplant, transmitting 'friendly' bacteria from a healthy individual into the patient's gut. Could this, and the exciting development of even more alternative treatments such as the use of predatory bacteria and antimicrobial peptides be the end of this battle against AMR?

AMR is one of the world's biggest problems, but is one that can be overcome. It is up to everyone to ensure that the growth of AMR is slowed so that there never comes a time when all bacteria are resistant to treatment via responsible anti-microbial use. To do this, countries must come together to improve antimicrobial drug regulation and drug use across humans, animals and the environment. And while coordinated action among many different countries can be difficult, it is important to remember that antimicrobial resistance knows no borders. Δ

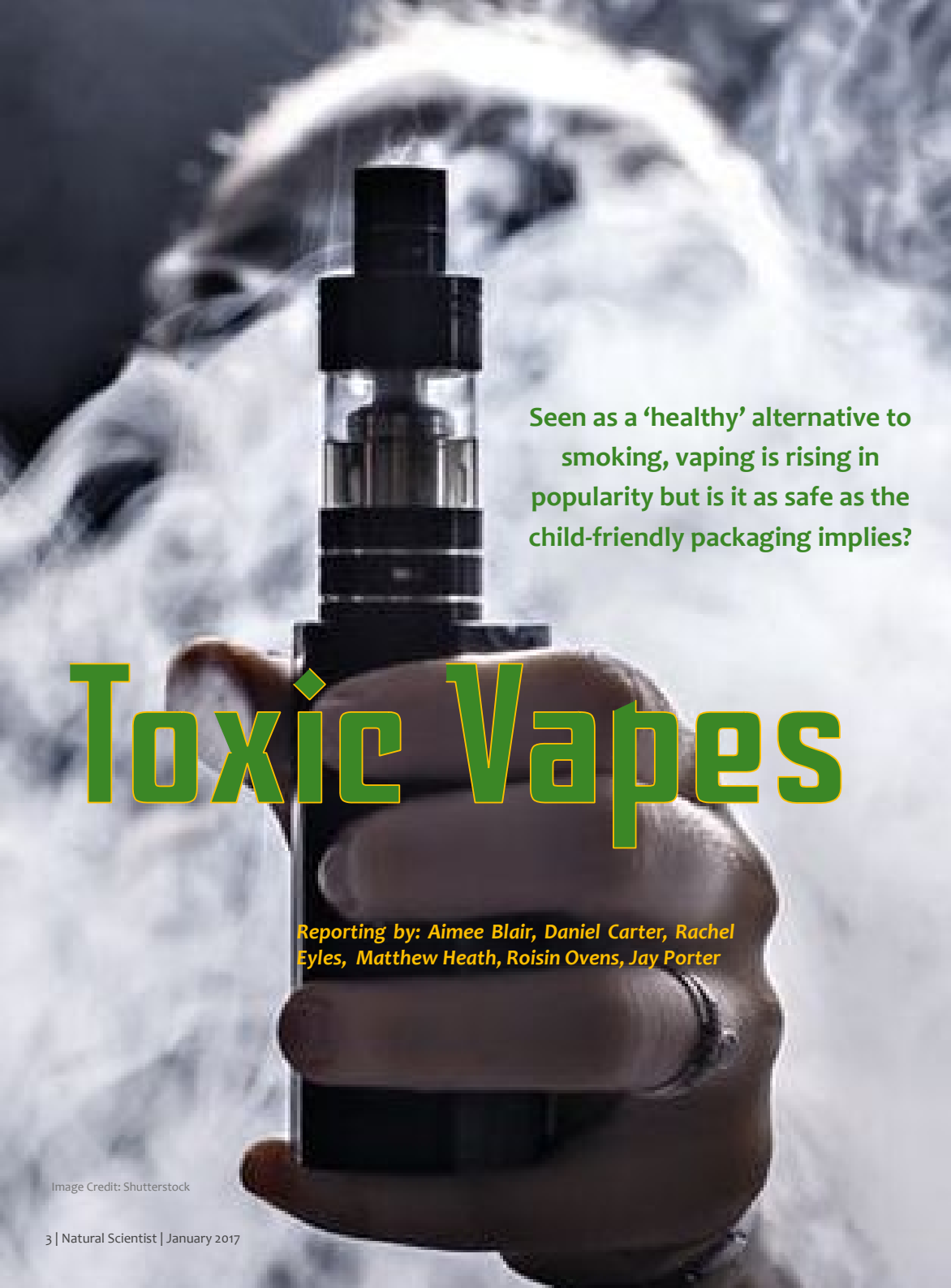


Image Credit: Shutterstock

Seen as a 'healthy' alternative to smoking, vaping is rising in popularity but is it as safe as the child-friendly packaging implies?

Toxic Vapes

Reporting by: Aimee Blair, Daniel Carter, Rachel Eyles, Matthew Heath, Roisin Ovens, Jay Porter

Without intention, you may have found yourself unwittingly walking into a cloud of bubblegum flavoured smoke this morning and immediately decided to direct the perpetrator a disapproving glare. They were most likely smoking an e-cigarette, otherwise known as electronic cigarettes, electronic nicotine delivery systems (ENDS) or vape-pen. Your disapproval could be warranted as little is known about the health risks of these devices, and whether they are in fact less dangerous than conventional tobacco cigarettes.

Despite the current trendy association with e-cigs and vaping (the action of inhaling the flavoured aerosol), testing of some e-cigs found the vapour to contain known carcinogens and toxic chemicals, as well as potentially toxic nanoparticles from the vaporising mechanism. This article explores the current issues surrounding e-cigs, comparing them to their notorious tobacco counterparts and examining whether or not you can be safe and vape.

One major concern in regards to e-cigs is the toxicity of the cartridge liquids and vapour. Studies have found that thermal degradation of propylene glycol and glycerol in e-liquids can occur when exposed to high temperatures, such as the heating element in e-cigs. These substances degrade into aldehydes, some of which are known human carcinogens. But when regular e-cig use is compared to regular cigarette use, these levels are around 6-50 times lower.

Yet there is the possibility of large concentrations of these aldehydes forming in newer e-cigs. When used on the highest heat setting, an action known as taking 'dry puffs', up to 15 times the amount of aldehydes are formed. Aldehydes are noticeable by regular vapers due to the offensive taste associated with them, but the same might not be said for new vapers. But despite the toxins, e-cigs are almost certainly better for you than conventional cigarettes as they do not contain tobacco in the same amounts.

Toxins in tobacco cause most of the diseases found graphically displayed on the front of cigarette boxes, including cancer and respiratory disease. As well as this, smoking cigarettes can damage DNA, causing mutations. But before you go out on an e-cig shopping spree, recent studies have found 31 harmful chemicals present in e-cigs, including 2 possible cancer-causing chemicals. Perhaps the largest risk with e-cigs is that they also contain nicotine.

Not only is nicotine highly addictive, it also stimulates adrenaline production which causes the heart to beat faster. Consequently, heart disease is a common illness associated with smoking, which is likely to be a risk of e-cigs as well. There have also been several cases of nicotine poisoning due to the direct ingestion of e-liquid, often by children, including three deaths. Other health concerns include possible metal poisoning from the e-cig heating elements and side effects caused by the inhalation of flavourings and colourings used in the manufacturing process, which are currently under-regulated.

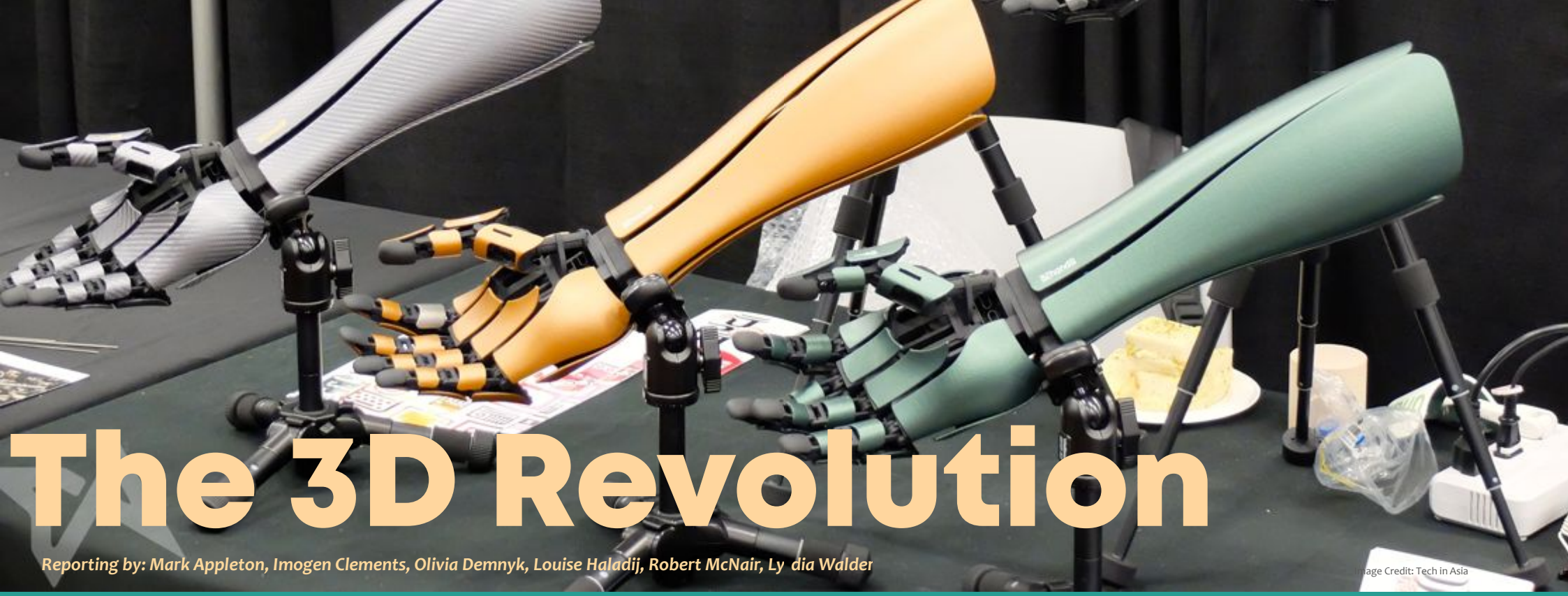
Health implications are not the only thing to worry about when it comes to e-cigs. Nicotine activates the reward system of the brain by triggering the release of the neurotransmitter, dopamine. The effects of nicotine don't last for long, as don't the feelings of reward. This results in the continuation of smoking to prevent withdrawal symptoms, such as anxiety, anger, hostility and a loss of social cooperation.

Like conventional cigarettes, e-cigs are also linked to behavioural addiction. They provide the opportunity for immediate reward, which relates to a classic psychological model of operant conditioning. Behaviour, such as vaping, can be taught through positive reinforcement, such as a nice flavour or validation from peers. Addiction is thus not only created through addictive substances, such as nicotine, but because the mind craves the reward.

Cigarette smoking is still prevalent worldwide, despite the negative impacts discussed. Not only does smoking harm yourself, smoking around others can increase their chances of developing all of the above. These factors have led cigarettes down the path to becoming more-or-less socially unacceptable, for example, being banned in public buildings and transport in the UK. Since e-cigs were introduced to markets in 2004, they have been awarded a similar status to cigarettes in regards to location banning, and are now included under cigarette law age restrictions.

But should we be so hasty as to dismiss e-cigs as dangerous? For smokers, e-cigs could greatly reduce morbidity and mortality rates and there is evidence to suggest that e-cigs may be a bridge to quitting altogether. The British Medical Journal stated this year that there has been a significant year-on-year reduction in cigarette smoking, and 170 thousand people replaced cigarettes with e-cigs from 2004 to 2013. Additionally, whilst second-hand smoke from cigarettes poses a serious health risk to those inhaling it, there is not similar risk with e-cigs due to the lack of lighted-end.

The new technology used in e-cigs is still not fully understood, and there is currently no long term evidence to clearly illustrate any chronic health implications. However, if e-cigs are indeed 'better for you' (for the time being at least), it might be wise for cigarette smokers to switch habits. Besides, for some of us, bubblegum flavoured smoke is definitely more pleasurable for the nostrils. Δ



The 3D Revolution

Reporting by: Mark Appleton, Imogen Clements, Olivia Demnyk, Louise Haladij, Robert McNair, Ly dia Walder

Image Credit: Tech in Asia

3D printing has moved from creating prototypes for traditional manufacture into producing useful medical devices. What's next for this emerging field?

Additive manufacturing (AM), widely known as 3D printing, is taking the medical industry by storm with advancements in areas from devices for complex individual surgery to mass produced prosthetic limbs for war casualties. AM can be traced back as far as the 1970s but is only now becoming more widely available in the real world due to its decrease in cost. As a result of this, 3D printing is now becoming commonplace in the medical industry.

The concept of 3D printing first occurring to Chuck Hull in 1983 when he was using UV light to harden table top coatings. In 1986, Hull coined the term 'stereolithography' which encompasses the method and apparatus for making solid objects by 'printing' thin layers of liquid material on top of each other, using ultra-violet (UV) light to harden each layer. The original material used was a liquid photopolymer, a type of polymer that changes its structural properties to a solid by crosslinking when exposed to UV light.

There are now a whole variety of different types of 3D printing, with the main differences being in the way the layers are built up and the materials used. Each technique has it's own advantages and disadvantages. Examples include Selective Laser Melting (SLM), Selective Laser Sintering (SLS) and Direct Metal Laser Sintering (DMLS). Sintering is the process of heating powdered metal to just under its melting point to cause it to fuse together a process which is widely used in AM.

Perhaps the most rapidly developing application of 3D printing is occurring in the field of prosthetics. Not only has it been able to print limbs including arms and hands, it is also a much more economically viable option than existing prosthetic methods. A 3D printed hand can be created for a mere $50, compared with a staggering $40,000 for an electrically operated prosthetic hand. Of course the functionalities of the resulting prosthetics are different, however, the printing of moveable multi-material parts is on the rise so printed limbs will soon be directly comparable in terms of functionality as well as appearance.

Due to civil war in Sudan there are many civilian casualties, who require specialist prosthetics. Previously, it would take a trained professional two weeks to cast and create a finished prosthetic for a patient, but thanks to people like Mick Ebeling and his radical 'Not Impossible' campaign, it is now possible for these people to have new prosthetics created for them in a much shorter time span using 3D printed parts. The campaign is producing prosthetics for a 70,000 person refugee camp and demonstrates the effectiveness of this technology when dealing with a large quantity of individuals.

3D printing is also being utilised in the surgical sector, providing surgeons with the ability to construct complex reconstructive implants that are tailored to each unique situation. This technique is used to print many different implants, including heart valves and bone replacements, using the advancements in medical imaging to create accurate models of the damaged area. For bone replacements, this technology is replacing the previous method of bending metal or moulded plates into the correct shape to create an implant, making the surgery quicker and more effective. These medical and financial factors continue to make 3D printing an extremely important area of research and more advances are expected.

As well as printing 'hard' implants, there is great potential for 3D printing in other areas of medicine: printing human tissue to be used for the testing of new drugs and cosmetics; printing personalised tablets when needed. The ultimate aim of many scientists is to be able to print an organ that is fully functioning and compatible with a person. To many, this is just a dream but, with the technological advancements in this area, it could be possible in the next decade.

The first organ likely to be printed for medical use is skin. There is hope that 3D printing technology could be used to treat victims of burns who currently undergo painful skin grafts, with skin taken from healthy areas to cover the burnt areas. In the future, skin could be printed using the patient's own cells to treat the affected area without the need for painful procedures.

3D printing could also be used to print other parts of the human body such as skin, ears, fingers and even whole limbs. It is likely the market for 3D printed body parts will grow considerably in the years to come due to high demand for false teeth, hip joints and replacement knees .

The printing of complete organs may still be a long way off, but, with the current advancements in the medical market, 3D printing has the potential to revolutionise medicine and play an essential part in the future of health care. Δ

Moo-ve Over Dairy

Reporting by Matthew Grammatico, Yasmin Hatt, Owain Llewellyn, Jack Matthews, Sophie Redgrave, Kamila Sala

Image Credit: iStock

Red, green or blue? The question most of us face every time we walk down the milk aisle. We know which milk has the most or least calories, but which type of milk is truly best for us and are alternatives better than dairy?

Statistics from a 2012 survey by *The Dairy Council* and *DairyCo* showed that 98% of UK residents eat or drink dairy products on a daily basis, with 93% consuming fresh milk regularly. Research has shown that 1 in 5 households across the UK are now substituting dairy milk with non-dairy alternatives. Astoundingly, the number of litres of non-dairy milk being sold increased by 155%, from 36 million to 92 million, over a very short timeframe from 2011 to 2013.

Due to the exceptionally low amount of fat and calories compared with the high calcium content in skimmed milk, many people may understandably assume that they should opt for a red-capped bottle during their next weekly shop. However, recent studies have shown that this is not necessarily the best option as skimmed milk has less of a number of essential fat-soluble nutrients such as vitamins A and E. Additionally, some experts have suggested that the saturated fats present may not cause any adverse effects in terms of heart health. Semi-skimmed, on the other hand, is both low enough in fat to be considered a 'low-fat' food and contains a great proportion of the vital nutrients needed to help maintain the body's natural defences. Furthermore, the green-capped variety is significantly ahead of the others when it comes to protein and vitamin B12 content, with the added benefit of containing a slightly lower amount of salt than its competitors, which helps lower bodily water-retention.

When considering the fact that many modern parents now lean towards alternatives to breast-feeding, whole milk is also advantageous in the sense that it can be introduced to infants as young as 1-year-old, whereas it is later for semi-skimmed (2-years) and skimmed (5-years).

Unfortunately, some people are unable to enjoy dairy milk without experiencing side effects such as diarrhoea or stomach bloating. This is due to a condition called lactose intolerance, which is the inability to digest lactose — a disaccharide found in dairy milk. It is caused by a deficiency of lactase, an enzyme responsible for the breakdown of lactose into glucose and galactose. Thus, when a person suffering from this condition drinks milk, lactose is able to pass through the digestive tract unchanged, consequently becoming a food source for the bacteria in the large intestine, resulting in a variety of abdominal symptoms.

Most mammals lose the ability to produce lactase after weaning, since the body no longer has a need for it. This affects approximately 75% of the human population around the world. however, the remaining 25% have developed lactase persistence, which enables them to produce lactase into adulthood. Lactase persistence is caused by relatively recent gene mutations, which are found frequently in populations with a long history of milk drinking. These mutations came about because of natural selection caused by increased livestock production over the past 10,000 years. Globally, lactose intolerance is more common than lactase persistence, with the former dominating in Asia.

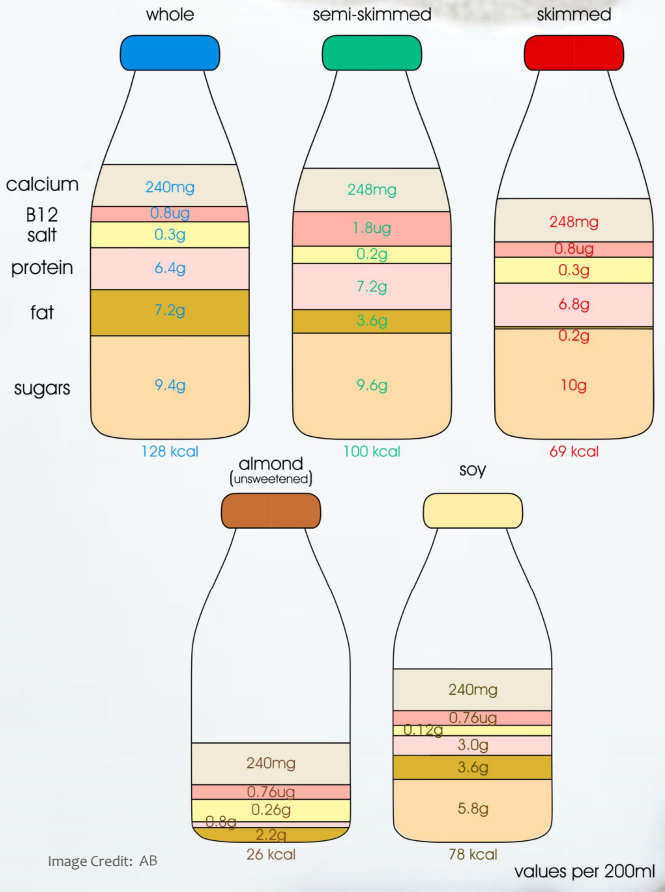


Image Credit: AB

Data for milk sold in UK supermarkets

Having seen the effects dairy milk can have, are dairy-free alternatives better for lactose intolerance sufferers? The answer is yes.

Almond 'milk' is a nut based alternative made mainly of water and almonds. It is popular amongst dieters due to being low in calories and having no artery-clogging saturated fat; only cholesterol-lowering healthy fats. Another plant based alternative is soy milk. It is made from soaking and grinding dried soya beans in water. The levels of protein in soy milk are higher, more comparable to dairy milk, but they can be higher in calories than other alternatives. Dairy-free alternatives are often artificially fortified with nutrients, such as vitamin B12, in order to reach the same nutritional levels as dairy milk, although not always so make sure to check the label! In addition to almond and soy milk there are other non-dairy and lactose-free options to choose from with more constantly appearing on the market.

Apart from the undeniable health benefits of alternative milk for those with lactose intolerance, it is also key to lowering our environmental footprint. The dairy industry is the leading cause of deforestation of the Amazon and it takes 144 gallons of water to make 1 gallon of dairy milk according to the 2012 report by the Innovation Centre for U.S Dairy so alternatives must be compared to these figures.

Whether we throw it on our cereal in the morning or toss it in our tea, milk plays a critical role in most of our lives. But, with so many options available it's often hard to choose. To put it simply, if you're trying to improve your health, attempting to save the planet or even just want to try something new, the supermarket shelves have got you covered. All things considered, 'red, green or blue?' is far from the only question we should be asking ourselves on our weekly shop. Δ

Test Tube Burger?

Meat is a fundamental part of the diet of the majority of the UK population and the concept of finding a substitute seems overwhelmingly difficult at first glance. Yet, with the impact the livestock industry is having on our planet, soon there may not be a choice. Thanks to recent advances in biotechnology however, a solution other than widespread veganism may be in sight; the Test Tube Burger.

Reporting by: Jamie Anderson, Laura Bacon, Harry Bates, Dominic Charles, Oliver Counter, Lucy Fannan and James Todd

The test-tube burger is a burger produced in a lab from a small sample of animal cells, left to develop into a slaughter-free, environmentally-friendly meat product. The tissue is taken from a live animal and the muscle cells are separated from the fat, then cultured in a bioreactor. This machine controls the cell environment keeping it similar to its native one, and here the cells are provided with essential nutrients such as amino acids and sugars. The innate contractions of the muscle cells combined with their tendency to merge causes layers to form and voila! You've acquired a slab of meat without killing the source animal.

Of course it isn't identical to your average burger; in fact, from a technical point of view it's actually healthier. Made solely from muscle cells, it is void of fat, cholesterol and many other molecules. Ironically, to make it taste like the meat we know and love, these can be added during the developmental phase. The fantastic thing about this though is that we can incorporate desirable molecules into the end products, like omega-3. And we are by no means limited to specific animals; this technique can be used on any cow, pig or bird whose end product is processed, such as sausages or nuggets.

The current global livestock industry contributes 18% of all greenhouse gas emissions, which is more than that of the entire human transportation industry combined. Unfortunately, this percentage doesn't even account for the vast amounts of land required to grow the livestock's' food supply, which with an ever-growing demand is being provided via means of deforestation. Experts also estimate that to produce 1 kilo of beef it requires approximately 7 kilos of grain. Then there's the 15,415 litre water requirement and the 27kg of CO_2 emissions. Compare these statistics to the grain-free requirement of cultured meat coupled with the 98% less land requirement to produce it, it would be controversial to deny that this method would be better for our environment in the long run. In a world with such an exploding total population, do we have the right to continue generating meat the way we always have?

Image Credit: Getty Images

However, cultured meat may not be the magic solution it at first seems. Hypothetically, if this new technology catches on and results in the mass abandonment of traditional meat, there could be some considerable economic consequences. In the US alone, the meat industry both directly and indirectly provides 6.2 million jobs whilst generating hundreds of billions of dollars for the economy. While a lot of these jobs may be transferable (such as packaging meat), there is a much tougher logistical problem; what would we do with the 19 billion chickens, 1.4 billion cows and 1 billion sheep and pigs that take up one third of our planets arable land? Furthermore, would governments allow cultured meat to become a reality? Can we be sure that there aren't any unforeseen long-term effects that could come from this technology? Would animal rights activists still approve of this as an alternative or consider eating it themselves? There are dozens of questions that cannot currently be definitively answered that might slow the progress of getting these products into the arms of the consumer. Unfortunately, they can only be answered in time.

So there you have it; a promising potential source of meat that keeps both animal-lovers and environmentalists happy. If, as anticipated, it becomes a realistic alternative, will the world accept it? Already companies are jumping onto this possibility with aims to have such products available to the public by the end of 2017. Δ

Two Mothers, One Father: The Latest Update on Mitochondrial Donation

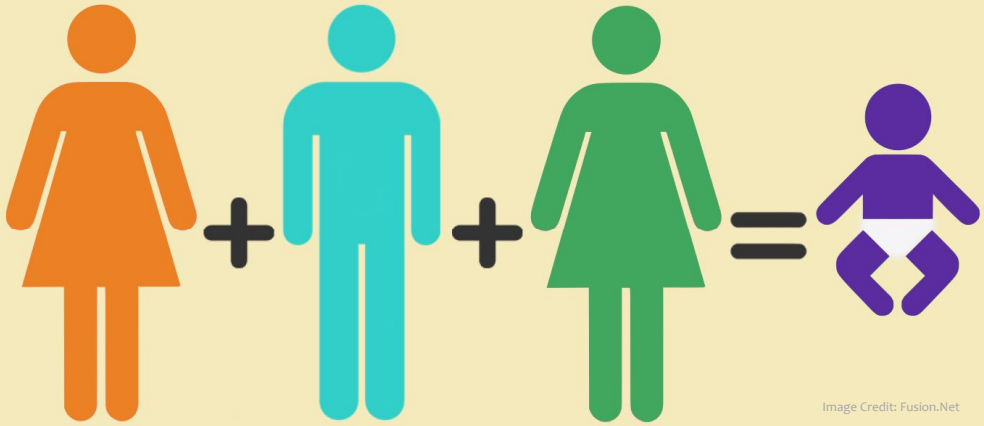


Image Credit: Fusion.Net

Reporting by Caroline Barwood, Gabriel Bryson, Catherine Cheesman, Helen Forrest, Jack Hart, Imogen Leaning, Eva Newman

In April the first baby was born using the new 3-parent technique of Maternal Spindle Transfer (MST). The new mother is a carrier of a mitochondrial defect, which has resulted in four miscarriages and the deaths of their previous two children. This exciting new technique has allowed the couple to become the proud parents of a healthy baby boy.

Serious mitochondrial disorders occur in 1 in every 6500 children in the UK and can be caused by mutations in the mitochondrial DNA (mtDNA) which accounts for 1% of a cell's total DNA. These disorders primarily impact tissues rich in mitochondria, such as the heart, skeletal muscles and brain. This reduces energy production and leads to a variety of symptoms including heart problems, muscle failure and seizures.

Mitochondrial donation has been developed to avoid passing on the mutated mtDNA responsible for mitochondrial diseases. In the recent case, the mother is a carrier of Leigh syndrome — a severe neurological disorder, which causes progressive loss of movement and mental abilities. This usually results in death before the age of three due to respiratory failure. Through this process the embryo received less than 1% of the mother's unhealthy mtDNA. As mtDNA is maternally inherited, a female child would risk passing unhealthy mtDNA onto her future children if the procedure were unsuccessful so, to avoid this, the embryo was selected to be male.

MST, the procedure used this year, involves removing the nucleus containing the mother's DNA from the egg leaving behind the maternal mtDNA, which is discarded. A donor egg is enucleated so that it contains only cytoplasm with healthy mitochondria. The mother's DNA is injected into the donor egg ready for fertilisation by the father's sperm using standard in vitro fertilisation (IVF) before being implanted into the mother's womb. 99.9% of the embryo's DNA will be inherited from the parents and the rest, comprised of mtDNA, will be from the donor.

There are many experimental studies that use a technique called pronuclear transfer, which aims to achieve the same outcome as MST. The processes are similar, however pronuclear transfer begins with fertilisation of the parental egg, as opposed to MST where fertilisation occurs after the transfer of the mother's DNA into a donor egg.

Previous attempts to create a 3-parent baby have used cytoplasmic transfer. The cytoplasm of a donor egg, containing healthy mtDNA, is injected into the egg of the mother who carries compromised mitochondria. This egg is then fertilised before being implanted into a surrogate mother's womb. In 1997, the first successful baby was born using this technique and there have been an estimated 30-50 births since.

Despite successful births , the ethics are under constant scrutiny. The birth of the child in April is not the first attempt at MST: throughout research many embryos are cultured and studied but do not come to term. But given the severity of mitochondrial diseases, many argue that the loss of embryos in research is outweighed by the benefits children conceived without defective mitochondria, will receive. There are issues specific to the different procedures used, for example using an embryo which is later destroyed in pronuclear transfer.

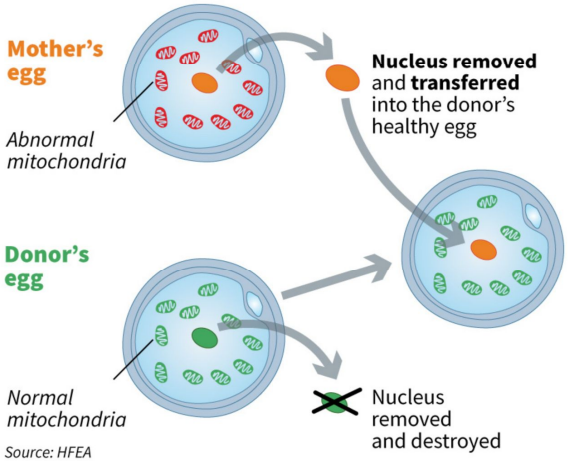
Some worry that these embryonic modifications may lead to further genetic alterations for non-medical reasons, producing so-called 'designer babies'. However, despite a recent development that allows parents to choose the sex of their baby, further selection of desirable traits is unlikely as there are multiple genes responsible for even the simplest of characteristics, such as eye colour.

It is clear to see that developments within the field of mitochondrial donation are a great success for medical science, and have the potential to change the lives of those with mitochondrial defects. However to ensure that the full benefits of mitochondrial donation are achieved, both the medical benefits and ethical issues should form the basis of an informed discussion about what is best for the child and mother. Δ

Three-parent babies

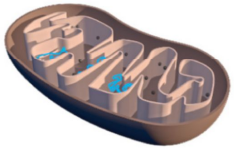
The technique involves using DNA from three people in order to prevent serious inherited diseases

In-vitro fertilisation (IVF) with mitochondrial DNA



Source: HFEA

Mitochondria



"Powerhouses" of the cell that have their own genome

Unknown risks

Uncertainties remain over the interaction between the mother's nuclear DNA and the donor's mitochondrial DNA

AFP

The Hawaiian Volcanoes: a Blessing or a Curse?

Do the volcanoes of Hawaii offer gifts to islands that su ffer from their destructive forces?

Image Credit: National Park Service Janice Wei

Hawaii is well known as an area of high volcanic activity. Many people would view this as a risk not worth taking. Reporters Hannah Gibbs, Jasper Holford, Charlotte Hostler, Lillian Matson, Adam Minchella, Mathias Schrieder outline how this apparent destructive force can be of benefit to the archipelago.

The Hawaiian archipelago is one of the most isolated in the world, 4000km away from the closest continent. Each island is formed by the movement of the Pacific tectonic plate over the Hawaiian hotspot in the Earth's underlying mantle. The main island of Hawaii consists of five individual shield volcanoes, only two of which are currently active - Mauna Loa and Kilauea, which has been erupting effusively since 1983. At the time of their nascence they were lifeless and desolate yet despite this, Hawaii is currently home to one of the most diverse and unique wildlife communities on the planet. The initial colonisation may have been challenging but subsequent founding populations have evolved at a rate much faster than the mainland species, evidenced by the 800 species of *drosopholid* flies believed to have progressed from a single ancestor.

The idiosyncratic and distinctive physicality of the islands not only drives the unique biodiversity, but also draws the attention of many tourists. Tourism is a prominent driver of the economy, attracting approximately 6.1 visitors for every permanent resident every year, making the destination not only a volcanic and evolutionary hotspot but also a centre for geotourism.

The effusive nature of Mauna Loa and Kilauea means that the chances of pyroclastic flows are minimal, nevertheless, an active volcano poses a number of threats to local inhabitants. Kilauea alone is known to release up to 4000 tons of sulphur dioxide daily; this toxic gas reacts in the atmosphere to produce vog — a combination of sulphate aerosols and sulphuric acid. These airborne particles can subsequently travel long distances to densely populated areas, where high levels of airborne ash leads to an increase in hospital admissions for respiratory conditions. Those who suffer from asthma and live downwind of volcanoes like Kilauea are 3 times more likely to have a serious asthma attack. Further hazards are created when the flow of lava reaches the ocean, reacts with sea water and produces laze; a vaporous form of hydrochloric acid. This lava haze has a noxious pH of 1.5-2.5 when precipitated as acid rain, over time damaging buildings and the environmental infrastructure. In November 2000, the bodies of two people were discovered close to where lava from Kilauea enters the sea. An autopsy report showed that both had died of pulmonary oedema, or swelling of the lungs due to the inhalation of laze.

It is not only human populations that suffer due to these harmful emissions. The explosive eruption of Kilauea in January 1960 buried approximately 5.6 square kilometres of ecologically diverse land, however, the degree of damage created by such eruptions is dependent on the environmental context. The elevation of the volcano generates gradients of precipitation; the side of the island with reduced rainfall sees century old lava flows remaining unoccupied by pioneering colonisers, whilst the rainy flank sees more recent flows already inhabited by communities nearing a stable climax.

Regardless of the risks posed by the islands volcanic nature, this unstable geological state also provides benefits and opportunities to the exceptional biodiversity and the welfare of the population. Adaptive radiation is a process made possible on Hawaii due to the range of extremely varied biomes, which in themselves afford a wealth of different niches. This is partly due to its volcanic nature, with Mauna Kea rising 14000m from the bottom of the ocean floor, regularly seeing snow on its summit whilst the coastal areas are often bathed in sunshine. These extreme conditions have provided opportunities for distinctive species to evolve such as the endemic 'Wekiu bugs', found only on the summit of Hawaii's largest volcano.

The volcanoes are not only a central attraction for tourists, but also increase the fertility and productivity of the farming land. The fine ash released when a volcano erupts quickly settles and is broken down into the surrounding soil. This ash is rich in minerals and nutrients essential for plant growth, such as magnesium and iron, both of which are utilised in the production of chlorophyll. As well as aiding agricultural development, the volcanic nature of Hawaii provides opportunities to exploit various types of renewable energy, in particular geothermal. Geothermal electricity is generated by pumping water deep underground where it becomes superheated, until it rises back to the surface and is used to drive the turbines in the process. The heat for this procedure is produced by the radio-active decay of elements in the earth's mantle and crust, making volcanic areas especially suitable for this type of energy. Despite the risk of hydrogen sulphide leaks, it has been estimated that in total there is more than enough potential for renewable energy on Hawaii to meet its entire energy requirements.

Volcanoes are often perceived solely as destructive forces, meaning that their influence to the development of the natural world is widely disregarded. Yet Hawaii embodies the perfect example of a small and distinctive island that thrives from its volcanic nature, providing a rich ecological environment, supporting the islands economy and assisting the endeavour to provide renewable energy for the near future. Δ

Reproducibility Crisis: Is it just Psychology?

Reporting by: Alexina Brown, Hannah Brown, James Dawson Natalie Kellman, Amara Lalemi-Jacobs, Freya Parker

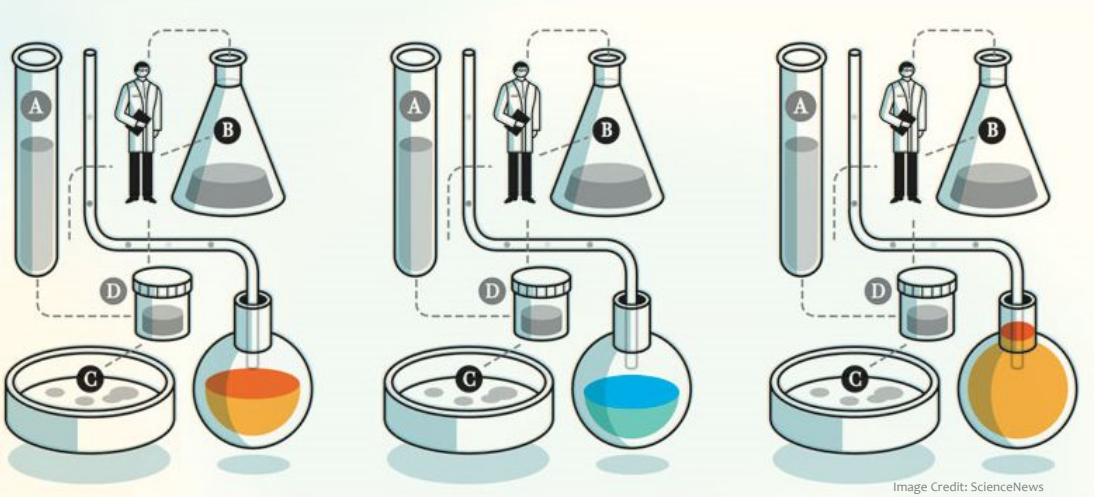


Image Credit: ScienceNews

A problem that appears to be sweeping scientific disciplines is that of the reproducibility crisis. Reproducibility is the ability of a study or experiment to be duplicated and is therefore a crucial factor in scientific research. Psychology is often at the forefront of criticism in this area, however is it fair to say this is the only science facing this crisis?

Recent findings have suggested that the reproducibility of nearly two thirds of psychology literature is questionable. In the biggest project of its kind, Brian Nosek, a social psychologist, and 269 co-authors repeated work reported in 98 original papers from three psychology journals, to see if they independently found the same results. The studies they investigated ranged from examining differences in how children and adults respond to fear stimuli, to effective ways to teach arithmetic. According to the replicators' assessments, shockingly only 39 of the 100 reproduction attempts were successful. Another method assessed whether a statistically significant effect could be found and produced an even bleaker result. 97% of the original studies reported a significant effect, while only 36% of reproduction studies found significant results.

Contrary to the stigma placed on psychology, it is not the only discipline to suffer from reproducibility issues. Computer science uses purely quantitative measures and is devoid of the demand characteristics that plague psychology but still suffers to some extent. This is often due to a lack of code and data being included in published papers and as such is a fault of the academic. Research by Vandewalle *et al* showed that, for 134 papers, only 33% of the data from the research and 9% of the code used in the studies was available online therefore openly reproducible. Additionally, in 2009, McCullough and McKitrick looked at trying to get access to author's data to reproduce studies in a range of disciplines, including environmental science and health and found this extremely difficult. A potential problem for reproducibility may therefore be access to methods and data.

Shockingly, the reproducibility crisis is further evident in the prestigious field of cancer research. Cancer researchers Glenn Begley and Lee Ellis made the remarkable discovery that scientists at the biotechnology company Amgen were unable to reproduce the majority of published pre-clinical research studies. Only 6 out of 53 landmark cancer studies could be reproduced! The Amgen researchers had deliberately chosen highly innovative cancer research papers, hoping that these would form the scientific basis for future cancer therapies. With this shocking success rate of only 11% can we remain optimistic in the future of cancer therapy?

It may come as a surprise that the list of scientific journals in which some of the irreproducible papers were published, includes the 'elite' of scientific publications. The renowned Nature journal tops the list with ten mentions, with Cancer Research coming closely behind with nine mentions, Cell and PNAS with six mentions, and Science with three. Recent research supports the short comings of these 'high impact journals' by discovering that 50% of survey respondents had experienced at least one episode of the inability to reproduce published data from these journals.

In some cases, even research in stem cell biology can be considered irreproducible. A prime example of this is the paper by Orlic *et al* (2001) published in Nature. Recent clinical trials using bone marrow cells to regenerate the heart did not succeed in improving heart function after heart attack, despite Orlic's earlier trials reporting the contrary. It is evident that even biology has several questions to answer for its role in the reproducibility crisis as well as its fellow 'softer' scientific fields. It appears that the reproducibility crisis is apparent in many scientific disciplines and that psychology is not the only field worthy of criticism. But why has this crisis arisen?

Some critics believe psychology specific reproducibility problems are due to few researchers reproducing experiments exactly once positive results are published, instead carrying out conceptual reproductions. Additionally, there appears to be a positive publication bias particularly evident in psychology. For example, the field is 5 times more likely to report a positive result than the space sciences.

Generally, the problems associated with reproducibility may be due to the way in which researchers are provided with funding and recognition, given that new and innovative discoveries rather than reproductions of previous work are more likely to secure funding and research positions.

A further possible reason for the lack of reproduction efforts is the 'impact factor' of scientific journals, which is an indicator of how often an average article published is cited. A high impact factor may lead to the assumption of credible research, without thorough examination of methodologies or attempts to reproduce the research. Moving forward, it may not necessarily be only the impact factor of a journal that should be trusted but the reproducibility of specific studies, which could be displayed alongside the original research.

To account for and improve the observed problems in reproducibility of scientific research, many initiatives are being created. An example of this is the congregation of a group of editors representing over 30 major journals in 2014, along with representatives from funding agencies and scientific leaders. This meeting led to the introduction of guidelines which encourage use of a checklist to ensure transparency in terms of the information given by scientists when reporting preclinical research. Another initiative in place in the field of psychology to combat the publication bias for novel research is PsycFileDrawer which has recently been set up in order for psychologists to submit any reproduction attempts.

Psychology, as well as all other scientific disciplines, has the opportunity now to rise to the occasion and find better ways to overcome biases and aid the process of transparent reporting, consequently eliminating the reproducibility crisis facing scientific research. Δ

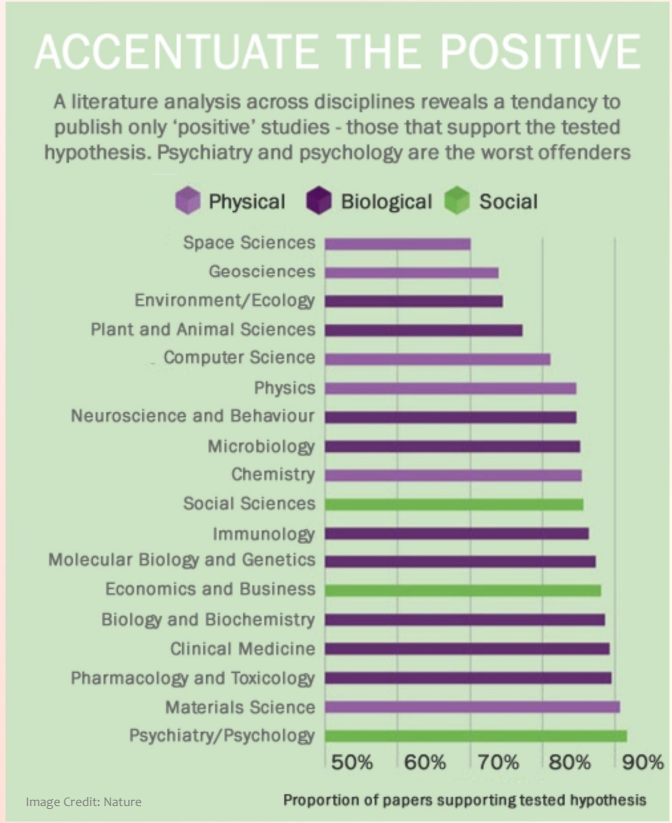


Image Credit: Nature

The Plastic Sea

Image Credit: PixaBay

Reported by: Francesca Hepworth, Matthew Lambert, Victoria Mee, Euan Morison, Nikita Shah & Ben Speake

Microplastics are pieces of plastic, less than 5mm in diameter, usually polyethylene – but can also be polypropylene, PET, polystyrene or nylon. These have risen in use in the cosmetics industry replacing biodegradable materials like nut shells, seeds, rice and salt crystals. Polyethylene microplastics are also used in scientific research, including fluid visualisation, microscopy, and industrial process testing.

Microplastics are also produced through degradation of larger pieces of plastic as a result of abrasion and UV radiation. Strong covalent bonds in polyethylene require a lot of energy to break the polymer down such as temperatures greater than 50°C. These conditions are not found in marine environments. It is this property which makes plastics non-biodegradable: they are broken into small pieces by mechanical forces, but fragments remain for hundreds of years. Because they are so small they easily pass through water treatment systems, ending up in rivers and oceans. A study found 90% of birds, along with most other marine life, ingest particles which impairs reproduction and embryonic growth, cause blockages and alter behaviour.

A recent study examined the impacts of microplastics on fish. Larval perch were reared in different environments of varying microbead concentrations. Results found exposure to concentrations similar to those presently found in marine ecosystems resulted in stunted growth and reduced response to predation. Perch were caught and eaten four times quicker by pike as they ignored their natural warnings that pike were near. Thus it can be said that exposure to microbeads can result in higher mortality rates in fish populations.

A single shower can result in 100,000 plastic particles entering the ocean. Persistent organic pollutants (POPs) are found in marine environments and due to their hydrophobic nature, they are likely absorbed by microbeads. POPs can then make their way into the food chain on the surfaces of the microbeads ingested by marine life and end up being eaten by humans. The exact risk to human health has not been studied, but the associated toxins and chemicals could cause harm. The observed impacts of microbeads has attracted international attention, resulting in campaigns for action from researchers and NGOs.

Removing microbeads from oceans is expensive and problematic so governments are instead working to ban their use, particularly in cosmetics, to prevent further pollution into the marine environment. The Netherlands was the first country to ban cosmetics containing microbeads (end of 2016) as well as backing legislation within the EU. In December 2015 the US signed the 'Microbead Free Waters Act' due to take effect 1 July 2017. and the UK government followed suit in September 2016 by announcing their plan to ban the manufacture and sale of cosmetics containing microbeads in the UK by the end of 2017. A growing number of companies have also pledged to stop using microbeads in their products, including Unilever, Johnson & Johnson and L'Oréal. Companies are returning to natural biodegradable exfoliates.

For those conscious about avoiding cosmetics containing microbeads, the 'beat the microbead' initiative has developed a free app that allows you to find out if a product has microbeads before you buy it by scanning the bar code. Perhaps the best way to reduce the influx of microbeads into the environment is the purchasing power of the general population. Δ

Biggest Stories of 2017

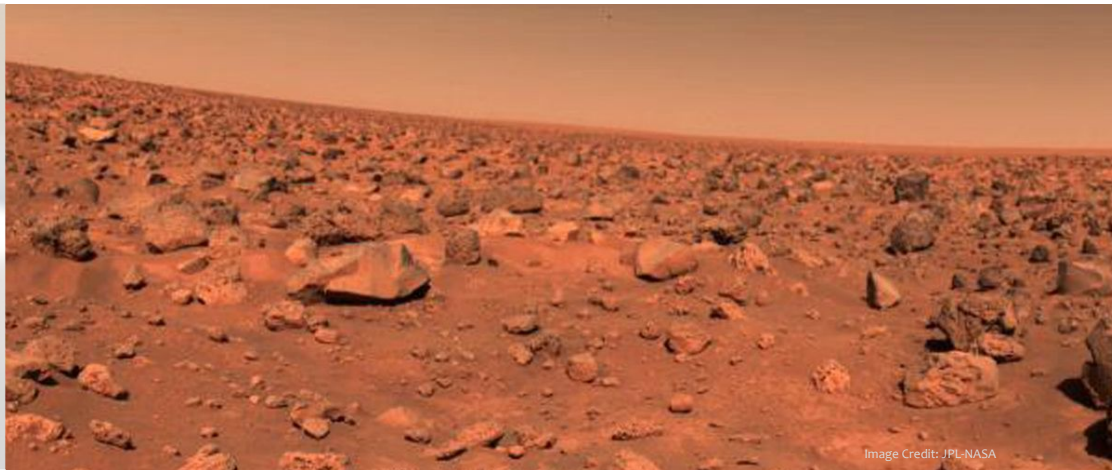


Image Credit: JPL-NASA

Is life on Mars as alien as we think?

Are we alone? The red planet Mars is often at the centre of any debate for life elsewhere in our solar system. Finding liquid water paves the way to answering one of the most profound questions of humanity. Charlie Carver, Vincent Hart, Jordan McRobert, Kieran O'Regan, Agata Rogalska, Bjork Tyril investigate whether life is out there.

Primordial Earth and Mars share many traits; significantly an atmosphere primarily composed of carbon dioxide, which was vital for the genesis of life on Earth. Therefore the emergence of life on Mars is not an impossible thought. However, the temperature (-67 °C average) creates the greatest challenge for life to exist on Mars. Nature is unable to utilise water in solid form, it is the fluidity which enables water to act as a medium for life – without this, Mars will remain sterile.

Recent images from NASA's Mars Reconnaissance orbiter provide evidence for the presence of liquid water on the planet's surface. Dark stains are visible across the Martian landscape, thought to be extremely salty water, which could possibly provide an inhospitable haven for life forms. The extreme salinity of Martian water decreases the freezing point and with surface temperatures rising to -23°C during summer, liquid water is plausible.

Organisms require certain conditions to survive. Mars has sources of energy vital for the engine of life, and carbon compounds to build biological structure, but liquid water was the last prerequisite for life to succeed. With the discovery of liquid water on Mars, the conditions can be compared with those at home.

The alien surface of Mars has similarities to areas here on Earth. Analogous environments such as Antarctica and the Atacama Desert are prime examples of our own terrestrial Mars. Antarctica with its sub-zero temperatures and irradiative pressures provides a harsh environment, yet life forms still exist. The Atacama Desert provides an arid, saline environment, only habitable to resilient microbes; extremophiles - a class of organisms adapted to withstand extreme environments.

Halophiles are a type of extremophile adapted to the pressures of living in salty conditions and they provide the most likely depiction for Martian life. They exploit unique mechanisms to counteract the osmotic pressures and the denaturing effects of salts: such as active transport of salt from their cytoplasm to prevent protein denaturation; accumulation of organic osmoprotectants to increase internal osmolality of the cell; and the active influx of potassium ions into the cytoplasm to prevent water loss via osmosis.

Life on Earth has proven to be able to exist in environments that closely resemble those on Mars, although there is no perfect analogy. As such, halophiles provide the most likely candidate for life on Mars, an organism far less alien than previously believed. However to confirm the possibility of extant life, further research and expeditions are needed. NASA's Mars rover 2020 mission seeks the answer to the most profound question: are we alone? Δ

Is Spider-man possible?

Could graphene-coated spiders be the answer to a real life spider-man?

Reporting by: Hannah Jackson, Lauren Mounteney, Fintan O'Connor, Matt Perkins, Edward Swales, Charlotte Taylor

As terrifying as you may find the critters that produce it, one cannot argue against the astounding capabilities of the super-material that is spider silk. Early civilisations recognised its potential for wound dressings and fishing lines, while in recent decades scientists have found applications in medicine, the military, even musical instruments. It has been shown to be one of the strongest natural materials in the world, but could spider silk be harnessed to make Spider-Man a realistic possibility?

Image Credit: Harvey Payne

Spiders secrete silk out of special glands initially as liquid proteins, before cells draw water away and hydrogen is pumped in to create an acid bath, thereby hardening the silk. From there, it is drawn out of the spinneret glands and stretched from fibroin protein molecules into long strands, which the spinnerets wind together to form the sturdy silk fibre.

Spiders can spin a variety of silk forms, each with a unique composition, range of properties and subsequent function. That said, all spider silk has a very high tensile strength and extreme flexibility, to the extent that it can stretch up to 150% of its natural length without breaking. Combining these properties enables the fibres to absorb more energy per weight than any man-made material. Other compounds present in the silk possess different special properties. For example, potassium hydrogen phosphate, a proton donor under aqueous conditions, gives the spider silk a pH of 4 making it resistant to bacteria and fungi. Spider silk is also known to be biodegradable, biocompatible and elicits no response from the immune system.

In terms of its composition, spider silk consists primarily of the protein fibroin, which contains many highly repetitive blocks of glycine and alanine residues and makes up 70% of the material. The blocks containing alanine mainly form α-helix and turn motifs, which together form a weakly oriented and amorphous matrix, affording the silk elasticity and extensibility. The predominantly glycine-containing regions, however, tend to form 'crystalline domains' of β-sheets with hydrophobic interactions and hydrogen bonds that contribute to the strength of the silk.

Due to its unique combination of properties and practical applications, scientists have tried to make synthetic spider silk in many ways. One such method of large scale production is by inserting the gene that codes for the production of the silk protein into E.coli. However, this is unable to entirely mimic the spider's natural silk as the fibres only have up to two thirds the strength. In order to overcome this, scientists have made graphene-enhanced spider silk by spraying a mixture of water and graphene particles onto spiders, although it is not fully understood how the graphene is incorporated into the silk. One theory is that the graphene coated the outside of the silk, although it has been suggested that the spiders incorporate chemicals from their surrounding environment into the silk as they spin it.

Having enhanced its production, would it actually be possible to create a Spider-Man able to swing from spider silk and with a suit capable of resisting bullets? The tensile strength of spider silk is quoted as being 1.3 GPa, meaning a strand with diameter similar to that of climbing rope (10 mm) could withstand a tension approximately equal to 102,000 N of force, enough to support the weight of 10 Renault Clios. The graphene silk, on the other hand, has a maximum tensile strength of 5.4 GPa, over four times that of standard spider silk and more than enough for the majority of Spider-Man's feats.

As for the bulletproof suit, spider silk is tougher than Kevlar, making it a perfect candidate for producing bulletproof clothing. However, the technology could go one step further. Spider silk has been successfully cultured with human skin cells to create a layer of membrane capable of resisting the impact of a 2.6 g bullet travelling at 325 metres per second, which, although slower than most bullets, would definitely provide some additional protection.

A friendly neighbourhood hero may be just around the corner! Δ