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A plastic eating enzyme: hope for recycling and fighting pollution

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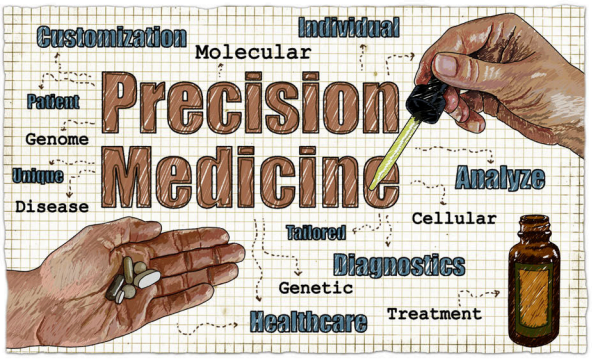

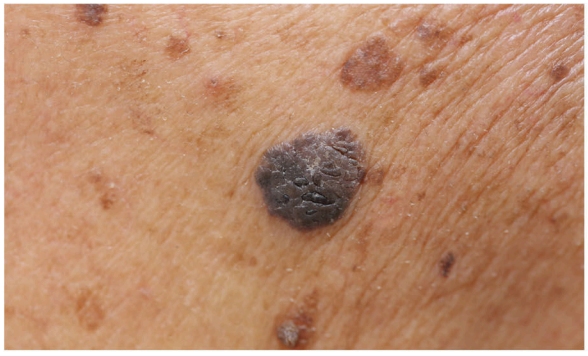

NOTE FROM THE FOUNDER & EDITOR-IN-CHIEF

We are excited to bring nine articles on relevant advances in science that have the potential to impact mankind - fighting plastic pollution, heart regeneration, safer and powerful batteries, cure for baldness and many more.

Hope you find them interesting!

Umesh Prasad

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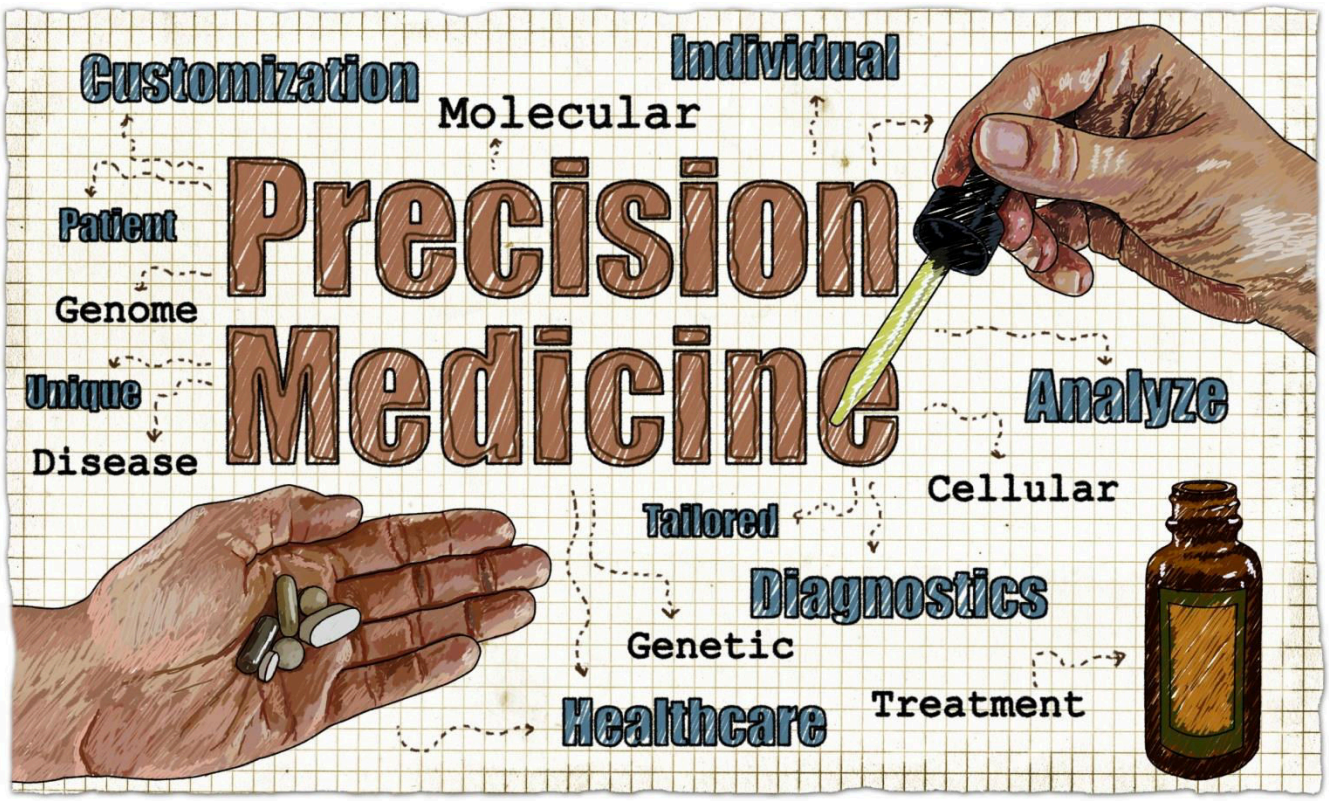
Precision medicine for cancer, neural disorders and cardiovascular diseases

New study shows a method to individually distinguish cells in the body in order to advance precision medicine or personalised therapeutic treatments



Precision medicine is a new model of healthcare in which genetic data, microbiome data and overall information on a patient's lifestyle, individual needs and surroundings is used to identify and classify a disease and then provide a better, customized or specialized therapeutic solution or even an effective prevention strategy in the future. This molecular-targeting approach has been progressing a lot in the

past decade and is now starting to make a strong impact as a new paradigm to 'classify, diagnose and treat' a disease. Precision medicine involves first data, and then tools/systems/techniques/technologies to interpret and process this data. It also needs proper regulations by statutory bodies and of course collaboration between health care workers because at every level humans are involved. The most crucial step in precision medicine is to understand the importance of genetic profiles of patients and how it needs to be interpreted efficiently. This will involve establishing reforms, carrying out training etc. Thus, the practise of precision medicine as of today is elusive because its implementation requires robust data infrastructure, and most importantly "mindset" reform. Interestingly, in 2015, over a quarter of all new drugs approved by the FDA, USA were such personalized medicines since these more "targeted" medicines are supported by smaller and shorter clinical trials with far more precisely defined patient selection criteria and turn out to be more efficient and successful. It is being estimated that personalized medicines in development will increase by almost 70% between by 2020.

Understanding a disease at the molecular level

A recent ground-breaking study has discovered a novel method which can provide insights into how a disease develops and spreads in the body at the molecular level. This understanding is seen to be crucial for developing what is discussed as 'precision medicine'. The method described in the study very efficiently and quickly recognizes the sub types of cells in the body, which can help in pinpointing the "exact" cells involved in a particular disease. This recognition has been achieved for the very first time and this makes the study published in *Nature Biotechnology* highly interesting and relevant for future of the medical field.

So, the question is how the cell types can be recognized in the body. There are about 37 trillion cells in a human body and thus distinguishing each cell individually cannot be adjudged to be a simple task. All cells in our body carry a genome - a complete set of genes encoded within the cell. This pattern of what genes inside the cell (or rather 'expressed' in the cell) is what makes a cell unique, for example is it a liver cell or a brain cell (neuron). These "similar" cells of one organ could still be distinctive from each other. A method demonstrated in 2017 showed that cell types that are being profiled can be distinguished by chemical markers which are inside the cell's DNA. These chemical markers are the pattern of methyl groups connected in each cell's DNA – referred to as the cell's "methylome". However, this method is very restrictive in the sense that it allows only single-cell sequencing. Researchers at the Oregon Health and Science University, USA, extended this existing method to profile thousands of cells simultaneously. So, this new method exhibits almost 40-fold increase in throughout and it adds unique DNA sequence combinations (or indexes) to each cell which are read out by a sequencing instrument. The team has used this method successfully to index several human cell lines and also mouse cells to reveal information on around 3200 single cells. The authors note that simultaneous read also leads to reduced costs bringing it down to approximately 50 cents (USD) when compared to $20 to $50 for one cell, making methylation libraries of single-cell DNA more cost-effective.

Aspects of precision medicine

This study is a ground breaking one and has the potential to advance the development of precision medicine or precise treatments for many conditions where cell type heterogeneity or diversity is present such as cancer, disorders which affect the brain (neuroscience) and cardiovascular disease which affect the heart. However, it is still a long way to go before we embrace precision medicine

because it requires good collaboration between pharma and healthcare workers which can include stakeholders, experts from various sectors, data analytics and consumer-protection groups. Scientific and technological advancements are definitely helping towards development of specialist, targeted therapies and creating more patient-centric solutions, because of which the future of precision medicine looks bright. Once diagnostics are in place, the patients "mindset" could be studied and understood so that empowered patients can themselves demand more information and choice on the options that they have leading to more cost-effective outcomes.

On negative aspect of molecularly based precision medicine is that it is not practicable or affordable for all therapy areas if we talk about and also across health systems, and it not going to be better anytime soon in the future. Gathering all information which is specific to patients firstly requires huge data storage. This information, specifically the genetic data is vulnerable to cyber-attacks therefore the security and privacy is at risk, also abuse of such data. The data being collected is mostly from volunteers therefore we are able to gather only a percentage of the entire population which can affect the design of technologies. And the most important aspect is the "ownership" of this data, who is the owner and why, that's a big question which is still to be addressed. Pharma companies will need to engage more collaboratively with governments and healthcare providers to gather support and momentum for targeted therapies but then the private genetic data being handed over to private companies is a big debate.

For chronic diseases likes diabetes or heart related conditions, digitally powered precision medicine is one alternative i.e. wearables which are normally scalable and are an affordable solution compared to providing expensive personalized care. Also, all medicines cannot really become precision medicine because health systems around the world are already burdened and its nearly impossible as well as ridiculously expensive to provide targeted therapies for small population groups, or those in middle-income or low-income countries. These therapies have to be provided in a well thought out and more focused manner. Population and people-based health care paradigms will continue to be important, with precision medicine approaches enhancing these in selected therapy areas and health care systems. It is still a long way before we can genetically map a population, interpret and analyse the information, store it safely and securely, and develop personalised recommendations and therapeutic treatments.

Source:

Mulqueen, R.M. et al. 2018, 'Highly scalable generation of DNA methylation profiles in singles cells', *Nature Biotechnology*, DOI: 10.1038/nbt.4112

Sugars and artificial sweeteners harmful in the same manner

Recent studies have shown that artificial sweeteners need to be approached with caution and they may not be good and can cause conditions like diabetes and obesity.

Sugar is said to be bad for our body mainly because it has high calories and zero nutritional value. All the types of delicious, fun foods and beverages that have high added sugar can displace more nutrition packed complex carbohydrates (which provide vitamins, minerals and fibre). Sugary foods also don't

provide the satiety that you get from other healthier foods, so people tend to consume more calories when they eat foods with more sugar in it leading to obesity and weight gain. This weight gain has been associated with high risk of heart disease, diabetes and certain types of cancer. Also, if you already have diabetes or a diabetes-related condition then having sugar will increase your blood sugar and your triglycerides, which is a risk factor for high blood pressure and heart disease. Simple sugar is also correlated with tooth cavities and decay, poor energy levels, and can lead to sugar cravings as the body never becomes fully satisfied from healthy foods.

What are artificial sweeteners

Artificial sweeteners are low-calorie or calorie-free chemical substances that are used in place of sugar to sweeten foods and drinks. They are found in thousands of products including beverages, desserts, ready-to-eat meals, chewing gum and toothpaste. Sweeteners provide a sweet taste but after they are consumed, unlike sugar, they don't increase one's blood sugar levels. Saccharin (sugar in Latin) was the first artificial sweetener discovered accidentally in 1897 by a Johns Hopkins University, USA researcher who was searching for new uses for coal tar derivatives. The discovery of another sweetener called cyclamate in 1937 coincided with the rise of diet soda (Pepsi and Coca Cola) in the 1950s and is still used today in diet Pepsi. Sweeteners are considered safe but to say that they are very healthy and have no side effect on our body is highly debatable.

Most food manufacturers make tall claims that sweeteners help prevent tooth decay, control blood sugar levels and reduce our calorie intake. Sweeteners also may have a stimulating effect on one's appetite and thus may play a role in weight gain and obesity. However, research on sweeteners and is still inconsistent, mixed, sometimes biased and very much ongoing. Most studies do not universally conclude the positive or negative aspects of artificial sweeteners but do stress upon the fact that these sweeteners can have negative health consequences as well[1].

Are artificial sweeteners all good or bad

Increased awareness about the health consequences of eating too much sugar - for all consumers of all age group - has led to the dramatic rise in the consumption of zero-calorie artificial sweeteners in past decades in the form of beverages or foods. It can be said that artificial sweeteners are now the most commonly used food additives worldwide. However, health experts argue that despite this publicity, awareness and usage there is still a continuous rise in obesity and diabetes cases.

Recent comprehensive research[2] showcased at 2018 Experimental Biology meeting shows that these sweeteners (sugar replacements) can cause health changes that are linked with diabetes and obesity and may not be good for anyone (normal or at-risk group). This is the largest research till date which successfully tracks biochemical changes in the body after consumption of sugar and sugar substitutes using an approach called "unbiased high-throughput metabolomics". The study was conducted in rats and cell cultures and the impact of substances on lining of blood vessels in the body was studied which suggested the health status. It was seen that both sugar and artificial sweeteners seem to exhibit negative effects relating to obesity and diabetes, just with different mechanisms.

Sugar and sweeteners both harmful

In this study, researchers fed rats (belonging to two different groups) diets which were high in glucose or fructose (two kinds of natural sugar), or aspartame or acesulfame potassium (the common zero-

calorie artificial sweeteners). After a period of three weeks they studied the differences in the concentrations of biochemicals, fats and amino acids in their blood samples. It is known that up to an extent our body machinery is very smart and can handle sugar, it's the excess chronic consumption over a long course of time that causes our natural machinery to break down.

The results of the study showed that the artificial sweetener acesulfame potassium appeared to accumulate in the blood leading to higher concentrations thus having a harmful effect on the cells which line the blood vessels. Negative unnatural changes in the fat and energy metabolism were seen upon replacing natural sugars with non-calorific artificial sweeteners. There cannot be a simple or clear conclusion from this study, the authors state, as more research is needed in this area. However, one aspect which is clear is that high dietary sugars and artificial sweeteners "both" have a negative health outcome in an otherwise healthy individual. The study also doesn't suggest to go cold turkey on these sweeteners by claiming that this would eliminate any risks of obesity or diabetes. The study rather propagates a "moderation" approach to rule out health risks and does not promote a blanket ban on artificial sweeteners as such.

Artificial sweeteners promote diabetes

Unpublished study[3] showcased at ENDO 2018, annual meeting of Endocrine Society USA, shows that consumption of low-calorie sweeteners could promote metabolic syndrome and cause diabetes especially in obese people. The metabolic syndrome consists of risks like high blood pressure, high blood sugar, abnormal cholesterol and high abdomen fat. These risks promote blood vessel and heart diseases leading to attacks and strokes along with a very high risk of diabetes. This study showed that in stem cells artificial sweeteners promoted fat accumulation in a dose dependent fashion unlike cells which have not been exposed to such artificial substances. This happens by increased glucose entry into the cells.

Also, when looking at fat samples from obese individuals who consumed these artificial sweeteners, it was found that that same thing was happening in the fat cells as well. Therefore, this is a cause of greater concern for people who have obesity or diabetes than normal weight counterparts because they have more insulin and more glucose in their blood. This only leads to increased risk of heart attack and strokes.

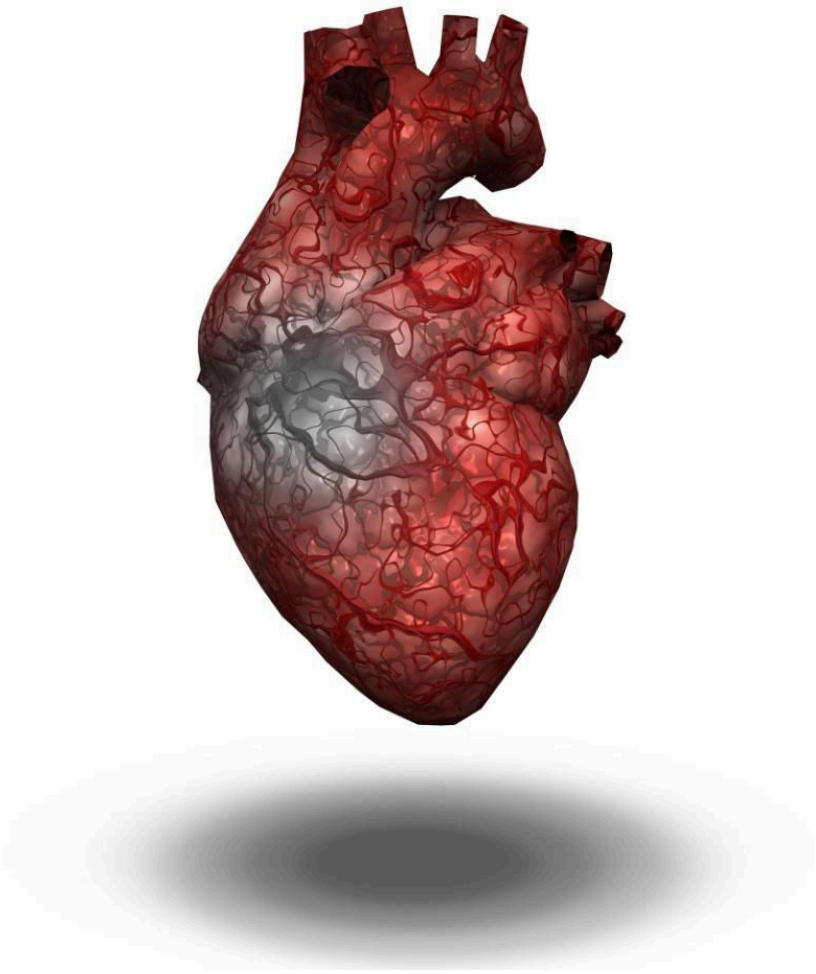
The word is not final on the artificial sweeteners as research is being carried out to understand their effects. But one thing is surely clear is that such artificial substances should also not be blindly consumed by the public and moderation approach must be applied to it as with the other "supposedly" healthy foods and drinks.

Source:

1 Jotham Suez et al. 2014, 'Artificial sweeteners induce glucose intolerance by altering the gut microbiota', *Nature*, vol. 514, pp.181–186, doi:10.1038/nature13793
2 EB 2018, Experimental Biology Meeting<https://plan.core-apps.com/eb2018/abstract/382e0c7eb95d6e76976fbc663612d58a>
3 ENDO 2018, annual meeting of Endocrine Society USA<https://www.endocrine.org/news-room/2018/consuming-low-calorie-sweeteners-may-predispose-overweight-individuals-to-diabetes>

Advances in regeneration of damaged heart

Recent twin studies have shown novel ways of regenerating a damaged heart



Heart failure affects at least 26 million people worldwide and is responsible for numerous fatal deaths. Due to a rise in the ageing population, taking care of the heart is becoming a need leading to rise in expenditures. No doubt there have been significant advances in therapeutic treatments for the heart

and lot of preventive steps are being taken, however, mortality and morbidity is still very high. The treatment options that are available are also very few and mostly it rests on heart-transplant for the patients who are really at the end stage and progressing towards complete heart failure.

Regeneration in our body

Our body does have an extraordinary capacity to heal itself, for example liver can be regenerated when is damaged, our skin also most of time, also one kidney could take over the function for two. Unfortunately, this is not true for most of our vital organs – including the heart. When a human heart is damaged – caused by a disease or an injury – the damage is perpetual. Example, after a heart attack, millions or billions of heart muscle cells can be lost forever. This loss weakens the heart gradually and leads to serious conditions like heart failure, or scars in the heart which can prove fatal. Heart failure usually results when cardiomyocytes (type of cells) become deficient.

Unlike newts and salamanders, human adults cannot spontaneously regrow damaged organs such as the heart. In a human embryo or when a baby is growing in the womb, heart cells divide and multiple which helps the heart to grow and develop for nine months. But, mammals including humans do not possess the ability to regenerate the heart as they lose this ability subsequently and completely after about a week of being born. Heart muscle cells lose their ability to divide and multiply and hence cannot regenerate. This unfortunately is true for other human cells too, brain, spinals cord etc. Since these adult cells cannot divide, the human body cannot replace the cells which are damaged or lost and this leads to diseases. Though this is also the reason why there is never a heart tumour (tumours are caused due to uncontrolled growth of cells). If, however, it can be made possible for these cells to divide again, this could lead to "regeneration" of a number of tissues and help to repair an organ.

When heart is damaged

The only one option which anyone has when suffering from a weak or damaged heart or a heart disease is to receive a heart transplant. This has multitude of aspects which generally affect a transplant from becoming a reality in most patients. Firstly, the heart that is donated by a "donor" has to be a healthy heart before the donor passed away, which means that the heart needs be harvested from young people who have died because of illness or injuries and these conditions have not affected their heart in any way. Also, the patient who is a prospective recipient must match with the donor heart to actually receive a transplant. This really translates into a long wait. As a possible alternative, the potential to be able to create new muscle in the heart through cell division could offer new hope to millions with damaged heart. Many procedures have been tried and tested by the scientific community, however, results so far have been ineffective.

Hope for heart regeneration

A new study published in *Cell*, researchers at University of California, San Francisco, have for the first time developed an efficient and stable method in animal models to make adult heart cells (cardiomyocytes) divide and thus potentially repair the damaged portion of the heart[1]. This is exactly the zone scientists have been trying to work on for decades. The authors identified four genes which are involved in cell division (that is cells which multiply on their own). When these genes were combined with the genes which cause mature cardiomyocytes to re-enter into a cell cycle, they saw that

cells were dividing and reproducing. So, when the function of these four essential genes was enhanced, the heart tissue showed regeneration. Also, after heart failure in a patient, this combination improves heart function. The cardiomyocytes exhibited 15-20 percent division in the current study (compared to 1 percent in earlier studies) cementing reliability and efficiency of this study. This study could technically be extended for other organs because of these four genes being the common feature. This is a very relevant work because any study on heart is firstly very complicated and secondly the delivery of genes has to be done with caution so as not to cause any tumours in the body. This work could turn into a very powerful approach for regenerating the heart and also other organs.

Another study by Stem Cell Institute, University of Cambridge, UK, has developed an innovative way to repair heart tissue such that a donor would not be required at all[2]. They have used stem cells to grow live patches of "heart muscle" in the laboratory which are though only 2.5 square centimetres, but they look like a powerful potential tool to treat patients who have heart failure. These patches, the authors say has bright prospective of getting naturally assimilated into a patient's heart i.e. it's a "fully functional" tissue which beats and contracts just like a normal heart muscle.

An earlier approach of injecting stem cells into the body to repair the heart has been unsuccessful because stem cells did not stay in the heart muscle but instead got lost in the blood. When compared to this, the current patch is a "live" and "beating" heart tissue that can be attached to an organ (in this case the heart) and thus any damage could be repaired. Such patches could be grown as and when there is a demand for a patient. This would essentially surpass the need to wait for a matching donor. These patches could also be grown using the heart patient's own cells eliminating the risks that are involved in organ transplant. Assimilating the patch into a damaged heart is also definitely an invasive procedure and requires correct electrical impulses for making the heart beat well-integrated with a patch. But the risks involved in this kind of procedure are better that a total heart transplant which is much more invasive. The team is getting ready for animal trials and hopefully clinical trials within 5 years before this could be used widely for heart patients.

Sources:

1. Mohamed et al. 2018, 'Regulation of Cell Cycle to Stimulate Adult Cardiomyocyte Proliferation and Cardiac Regeneration', *Cell*, DOI: 10.1016/j.cell.2018.02.0142.

2. University of Cambridge 2018, 'Patching up a broken heart', accessed 1May 2018, <http://www.cam.ac.uk/research/features/patching-up-a-broken-heart>.

A step towards finding a cure for greying and baldness

Researchers have identified a group of cells in the hair follicles of mice which are important both in forming the hair shaft to allow hair growth, and also in maintaining hair colour in a study aimed at identifying possible treatments for hair greying and balding

Hair loss in humans is caused by a variety of reasons, including genetics, thyroid problems, hormonal chances, cancer treatment (chemotherapy), as side effect of medications and/or other health conditions. Hair loss though is more common in men, anyone for that matter can experience hair loss

due to any of these underlying conditions. It's safe to say that hair loss or hair thinning is devastating to anyone, men or women, and it can directly result in low self-esteem, anxiety, depression and/or other emotional issues. Why this happens is mostly related to culture and societal norms. Since luxurious hair is associated with youth, beauty and good health. And so, for most people, whether male or female, their hair gives them confidence and makes them look and feel beautiful. Baldness in men occurs when there is excessive hair loss from one's scalp. The most common reason for this is the hereditary hair loss with age and this kind of baldness does have a "cure" yet. Some people accept it and they cover or camouflage is by hairstyles, hats, scarves etc. However, inside their hearts everyone is looking for a magic solution which can help cure this problem of hair loss.

Treatments available for hair loss

Few possible treatments for hair loss are available. Researchers have claimed that hair loss might be reversible or at least the thinning of hair might be slowed down in cases in which complete hair loss has not taken place. Treatments including medications and even surgery have been proposed to slow down hair loss and promote hair growth. Even for conditions like patchy hair loss (which is caused due to a genetic condition called alopecia areata) it is being claimed that hair may regrow completely within a year of the treatment. Some of these treatments are carried out unlicensed and they tend to put the patient on risk and most of them are ineffective after the first round of treatment, i.e. once successful, the patient's condition reverts back to the original in no time, leading to the patients repeating the same treatment over and over.

Scientists worldwide are trying to understand the root cause of hair loss and also hair greying for a very long time and trying to come up with a solution which not only can suit everyone but will also have minimal side effects. However, it has not been easy journey and lots of hits and misses have taken place.

Breakthrough study

A hopeful breakthrough study conducted at UT Southwestern University, USA, researchers have learned the reason behind our hair turning grey and they have also identified which cells exactly directly give rise to hair. Interestingly, the project was initially aimed at trying to understand the various forms of tumours in humans by studying a rare genetic condition called neurofibromatosis in mice which causes benign tumours to develop on covering or sheath of nerves. However, the study took a turn and researchers instead discovered the role of a protein called KROX20 in hair colour which then lead to this unique finding. Authors state that this study has brought upon enough knowledge to be able to address the problem of hair loss and hair greying. They suggest that a topical compound (a cream or an ointment) can be created which can safely deliver the necessary gene to the hair follicles to rectify the problems.

Understanding greying of hair and baldness

The protein KROX20 (also termed EGR2) has been more commonly associated with nerve development. While performing the experiments researchers saw the occurrence of full grey fur on one mice which then led the authors to further probe the possible role of this protein in hair growth and pigmentation. It was understood that protein KROX20 'became' skin cells which then 'become' the hair shaft from where the hair originates making it clear that KROX20 protein had a prominent role. These hair precursor cells produce a protein called stem cell factor (SCF) which is shown to be very essential for

hair pigmentation thus is responsible for greying of hair because pigmented hair means the hair has lost its colour. When this SCF gene in the hair precursor cells was deleted in mice, their coats lost their colour because no new pigment (melanin) was being deposited into the hair as it grew. This process started early on in the mice's lives and the animal's hair turned white starting from 30 days and then after nine months all their hair was white (because of no melanin being produced). And further, if the KROX20-producing cells were removed then mice grew no hair and they became bald. These two tests fully explained the important genes needed for both hair growth and its colour.

Though these two theories are already known to be involved in hair making and pigmentation but the unknown aspect discovered in this study was the detailed account of what happens when the stem cells move down to the base of the hair follicles, which cells in the hair follicles produce SCF and which cells eventually make the KROX20 protein. The exact cells and their details have been formulated for the first time in this study published in *Genes and Development.* It's been made clear that cells with functioning KROX20 and SCF, move up the base of the hair follicle and interact with pigment-producing melanocyte cells and then eventually grow into pigmented (mature pigment = colour) hair. This study was aimed at better understanding the identities of progenitor cells in the matrix and the mechanisms by which they regulate hair shaft components.

Study ageing and finding a cure of baldness

This revelation can be used to further study why people when they age start getting grey hairs, why hair thinning is usually seen in older people and the ultimate – male pattern baldness which is genetic. This could also help to further understand why greying of hair and hair loss are the significant first signs of ageing in humans. Also, if the root cause of greying hair is known, can loss of hair colour be stopped and if its already happened can it be reversed and how. This research has definitely achieved a very detailed understanding of an important biological process which can help to figure out ways to stop, alter or correct a problem. The study itself is at a very early stage and the current work done in mice needs to be extended to humans by conducting suitable tests on human cells in the laboratory before design of treatments can begin.

Source:

Liao C-P, Booker RC, Morrison SJ, Le LQ. 2017, 'Identification of hair shaft progenitors that create a niche for hair pigmentation'. *Genes & Development*. vol. 31, no. 8, pp.744-756, DOI:10. 1101/gad.298703.117.

New nanofiber dressing for efficient wound healing

Recent studies have developed new wound dressings which accelerate healing and improve tissue regeneration in wounds.

Scientists discovered a very important aspect of wound healing in the late 1970s when the understanding of this process was at a very early stage. It was seen that any wounds which were incurred in a baby before the seventh month of pregnancy left no scars and there is fast scar less healing in early development of foetuses. This led the researchers to try and recreate or replicate these unique properties of the foetal skin which could be the used for regenerative medicine. The foetal skin is known to have very high levels of a protein called fibronectin. This protein fibronectin generally assembles into an extracellular matrix which in turn helps or rather promotes cell binding and adhesion. What is unique is that this property is very exclusive to foetal skin and is not found in adult cells. To elaborate this property further, fibronectin protein has two unique structures globular and fibrous. The globular structure i.e. the one spherical in shape is found in blood, while tissues in the body are fibrous. Fibronectins have always been seen as potential good candidates for wound healing but manufacturing fibrous fibronectins has remained a challenge so far. In dual studies published recently, researchers have provided insights into two different types of nanofiber dressings which use naturally-occurring proteins in plants and animals. These dressings are touted as very efficient in healing and re growing tissue in a wound. These current studies have pioneered the possibility of creating and developing nanofibers for wound healing. The whole idea of the authors was to creating dressings with the aim of developing therapeutics for wounds, especially those inflicted during war. The healing of such wounds is a painful process and is underserved by the wound therapeutics currently available.

In the first study published in *Biomaterials*, researchers from Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering have manufactured fibrous fibronectin on a platform called Rotary Jet-Spinning (RJS), developed in house[1]. They have described a wound dressing by using foetal tissue. The 2-step process was straightforward in which first a liquid polymer solution (here, globular fibronectin dissolved in a solvent) is loaded into a reservoir and is thrusted into a tiny opening by a centrifugal force as this machine spins. When this solution leaves the reservoir, the solvent evaporates and the polymers solidify. This strong centrifugal force unfolds the globular fibronectin into small, thin fibres (less than one micrometre in diameter). These fibres can be collected make wound dressing or bandages. Testing in animals showed that wounds treated with this new fibronectin dressing showed 84 percent restoration of skin tissue within only 20 days, while the normal dressings restored 55.6 percent.

The working of this dressing has been well explained. The dressing integrates into the wound and acts like an instructive scaffold which then allows different stem cells to carry out the necessary regeneration and assistance for the healing process of tissues in the wound. The material is eventually absorbed by the body. The wounds treated with this fibronectin dressing have very normal epidermal thickness and also dermal architecture. Even the hair was regrown in the area of the wound after it was healed. This is a big achievement because hair regrowth has remained one of the main challenges in the field of wound healing. When compared to standard processes of skin regeneration, this procedure efficiently repaired tissue and also regenerated hair follicle using the capability of just one material. Obviously, such an approach has significant advantages for translating the research into actual use. These fibronectin dressings can be apt and useful for small wounds, especially on face and hands where it's important to prevent any scarring.

In their second study published in *Advanced Healthcare Materials,* researchers developed a soy-based nanofiber which promoted wound healing[2]. Soy protein contains, firstly, estrogen-like molecules (which are proven to accelerate wound healing) and secondly, bioactive molecules which contribute in building and supporting human cells in the body. These molecule types are routinely used in reproductive medicine. It's very interesting that whenever the estrogen levels are higher in a woman's body, their cuts or bruises heal faster. This is the reason pregnant women heal faster because they have such high estrogen. This is also the reason that an unborn baby inside the womb express scar-less wound healing because of the high levels of estrogen present. Researchers used the same RJS to spin ultra-thin soy fibres into wound dressings. These experiments also showed that soy and cellulose-based dressings on wound show 72 percent increased and improved healing, compared to only 21 percent in wounds without this soy protein dressing making them extremely promising. These dressings are inexpensive and thus optimally suited for large-scale usage, example for burn victims. Such cost-effective scaffolds are considered a revelation and have enormous potential for regenerative, especially for the militia, dressings under the umbrella of nanofiber technology. The Harvard Office of Technology Development has protected the intellectual property relating to these projects and is exploring commercialization opportunities.

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2. SeungkukAhn et al. 2018, 'Soy Protein/Cellulose Nanofiber Scaffolds Mimicking Skin Extracellular Matrix for Enhanced Wound Healing. Advanced Healthcare Materials', 1701175 DOI: 10.1002/adhm.201701175

A plastic eating enzyme: hope for recycling and fighting pollution

Researchers have identified and engineered an enzyme which can digest and consume some of our most commonly polluting plastics providing a hope for recycling and fighting pollution

Polluting plastics is the biggest environmental challenge worldwide in the form of plastic pollution and the best solution to this problem still remains elusive. Most plastics are made from petroleum or natural gas which are non-renewable resources that are extracted and processed using energy-intensive techniques. Thus, their manufacturing and production itself is very destructive for fragile ecosystems. Also, the destruction of plastic (mostly by incineration) causes air, water and land pollution. About 79 per cent of the plastic produced over the last 70 years has been thrown away, either into landfill sites or into the general environment while only about nine per cent is recycled with the rest incinerated.

This process of incineration exposes vulnerable workers to toxic chemicals which include cancer-causing substances. The oceans are said to contain some 51 trillion microplastic particles and are slowly depleting the marine life. Some of the plastic microparticles get blown away in air leading to pollution and it's a real possibility that we might be inhaling them. No one could have predicted in the 1960s that the advent and popularity of plastics would one day become a burden with huge plastic waste found floating in our beautiful oceans and air and dumped on our precious lands.

Plastic – a big problem

The plastic packaging is the biggest threat and most corrupt use of plastics. But the problem is that the plastic bag is everywhere, used for every little purpose and there is no control over its usage. This kind of synthetic plastic does not biodegrade, instead just sits and accumulates in landfills and contributes to environmental pollution. There have been initiatives for "complete plastic ban", especially polystyrene which is used in packaging. However, this is not leading to desired results as plastic is still ubiquitous in land, air and water and is ever growing. Safe to say that plastic may not even be visible to the naked eye all the time but it's everywhere! It is sad that scientists who discovered the "extraordinary" plastic material are unable to tackle the material's recycling and dispose problem.

A new enzyme which "eats" plastic

In a breakthrough study published in *Proceedings of the National Academy of Sciences USA*, researchers have discovered a known natural enzyme which feeds on plastic. This was a chance discovery while they were examining the structure of an enzyme which was generally found in waste which is ready to go for recycling at a centre in Japan. It was discovered that this enzyme, called Ideonella Sakaiensis 201-F6, is able to "eat" or "feed off" the patented plastic PET or polyethylene terephthalate which is most commonly used in millions of tons of plastic bottles. The enzyme basically allowed the bacterium to degrade the plastic as their food source. No recycling solutions currently exists for PET and these plastic bottles persist for more than hundreds of years in the environment. So, this study led by teams at the University of Portsmouth and the United States Department of Energy's National Renewable Energy Laboratory (NREL) has generated immense hope.

The original goal of the authors was to determine the three-dimensional crystal structure of this natural enzyme (called PETase) and use this information to understand how exactly this enzyme works. They used an intense beam of X-rays - which are 10 billion times brighter than sun - to elucidate the structure by seeing individual atoms. Such powerful beams enabled to understand the inner working of the enzyme and provided the correct blueprints to be able to engineer faster and more efficient enzymes. It was discovered that PETase looks very similar to another enzyme called cutinase except that PETase has a special feature and a more "open" active site, which is thought to accommodate human-made polymers (instead of the natural ones). These differences immediately indicated that PETasemay be more evolved specially in a PET-containing environment and thus could degrade PET. To test what they were thinking researchers mutated thePETase active site to make it look more like cutinase. What followed was a totally unexpected outcome, the PETase mutant was able to degrade PET even better than the natural PETase.

Thus, to their luck, in the process of understanding and trying to improve the natural enzyme's capability, they ended up accidently engineering a new enzyme which was even better than the natural enzyme in breaking down PET plastics. This enzyme could also degrade polyethylene furandicarboxylate, or PEF, a bio-based substitute for PET plastics. This generated hope to tackle other

substrates like PEF (Polyethylene Furanoate) or even PBS (Polybutylene succinate). The tools for enzyme engineering and evolution can be continually applied for further improvement. Researchers are looking at a way for improving the enzyme so that its function could be incorporated in a powerful large-scale industrial set up. The authors state that the engineering process is very much similar to enzymes which are currently being used in bio-washing detergents or in manufacture of biofuels. Simply put, the technology exists and thus industrial viability should be achievable in the coming years.

However, this discovery is also laden with some apprehensions which will take time to be resolved after further work has been carried out. Firstly, the enzyme breaks down larger pieces of plastics into smaller pieces, therefore it does support recycling of plastic bottles but all this plastic needs to be first recovered. This "smaller" plastic when recovered could be used to turn them back to plastic bottles. The enzyme cannot really "go and find plastic on its own" in the environment. One proposed option could be to plant this enzyme into some bacteria which can start breaking down plastic at a higher rate while withstanding high temperatures. Also, long term impact of this enzyme still needs to be comprehended.

It is absolutely no doubt that the impact of such an innovative solution to tackle plastic waste would be very high on a global scale. The world has been trying to tackle the plastic problem ever since the advent of plastic itself. There have been laws banning single-plastic use and also recycled plastic is now favoured everywhere. Even small steps like banning plastic carry bags in supermarkets has been all the over the media. The point is, we really need to act fast if we would like to preserve our planet from plastic pollution.

Though we must still carry on adopting recycling in our everyday life while encouraging our children to do so as well. We still need a good long-term solution which can go hand on hand with our own individual efforts. This research is preliminary and it only marks a beginning but it is definitely aiming at tackling one of the biggest problems which mankind or our planet is facing.

Source:
Harry P et al. 2018, 'Characterization and engineering of a plastic-degrading aromatic polyesterase', *Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.1718804115

A new tooth-mounted nutrition tracker

Recent study has developed a new tooth mounted tracker which records what we are eating and is the next trend to be added to the list of health/fitness trackers

Different kinds of health and fitness trackers have been becoming very popular in the past decade. All categories of people are adopting these trackers, whether they are trying to lose weight, are trying to build extra muscle mass or are just normal people who take fitness and health seriously and also want to look good. Going to the gym has been popular, but now personalised methods like using fitness and activity trackers are a rage. Such health and fitness wearables consist of watches and activity trackers which are just gadgets on the first glimpse but they are helping people to achieve their health and fitness goals. Many advanced functionalities are now being added to these wearable and almost all big technology companies are eyeing this market. The functions include which have been incorporated so far include monitoring of heart rate, calorie counters, counters for different kinds of physical activities. These sensors are now used by people in their day-to-day lives for monitoring their bodies – including heart rate, blood oxygen levels, blood pressure, sleep pattern and diet. It's remarkable how easy it has become to monitor our daily activities using these fancy gadgets.

Fitness monitors as wearables on wrists is surely not a new concept. A new study has went a step ahead by developing a wireless sensor, which can directly be mounted on a person's tooth and it can exactly track and record what a person has eaten or drank in real time. This is really the next level of monitoring! The study published in *Advanced Materials*, describes this tooth mounted wireless sensor as a device which can transmit information about oral consumption by a person including his/her glucose or sugar, salt and alcohol intake. The size of this sensor stands at a tiny 2mm x 2mm and it is square in shape and it can flexibly conform and bind to the irregular surface of our tooth. Therefore, it comes in contact with whatever happens to pass through a person's mouth. Once there is data available on this sensor, managing and interpreting this data can help us to identify the patterns of consumption for a person and it can really point out the improvements that can or should be made in that person's diet regime so as to manage their health in a better way. Foremost, this sensor can keep an accurate log and thus can bring awareness about one's nutritional intake as that is of supreme importance for health.

This sensor developed by researchers at Tufts University School of Engineering, USA is made up of three layers and looked like a custom microchip. The first layer is the "bioresponsive" layer, which is made up of silk fibres of water-based gels and has the ability to absorb the chemicals being detected. This layer is installed between outer layers consisting of square-shaped two gold (or titanium) rings. All the three layers together act as a tiny antenna and collect and transmit waves (in the radiofrequency spectrum) based upon the incoming and allow the sensor to wirelessly transfer information about nutrients consumption to a mobile device. This transmission is achieved by using the powers of material science that lets the sensor shift its electrical properties depending on what chemical its layer comes into contact with. Example, if a person is consuming say a salty snack like nachos, the salt present in this food will cause the sensor to absorb and transmit a "specific spectrum and intensity" in the wave telling us that salt was consumed.

The authors say that such a device, though currently in its experimental stage, could have a variety of applications. This device would definitely have medical and lifestyle applications as it can track our nutrition and can help us to improve our health. Aggressive and efficient nutrition monitoring using such a device can definitely be a part of nutrition/diet management. Also, if this device can help sample and monitor analytes in one's oral cavity then it can be useful for monitoring a person's dental health.

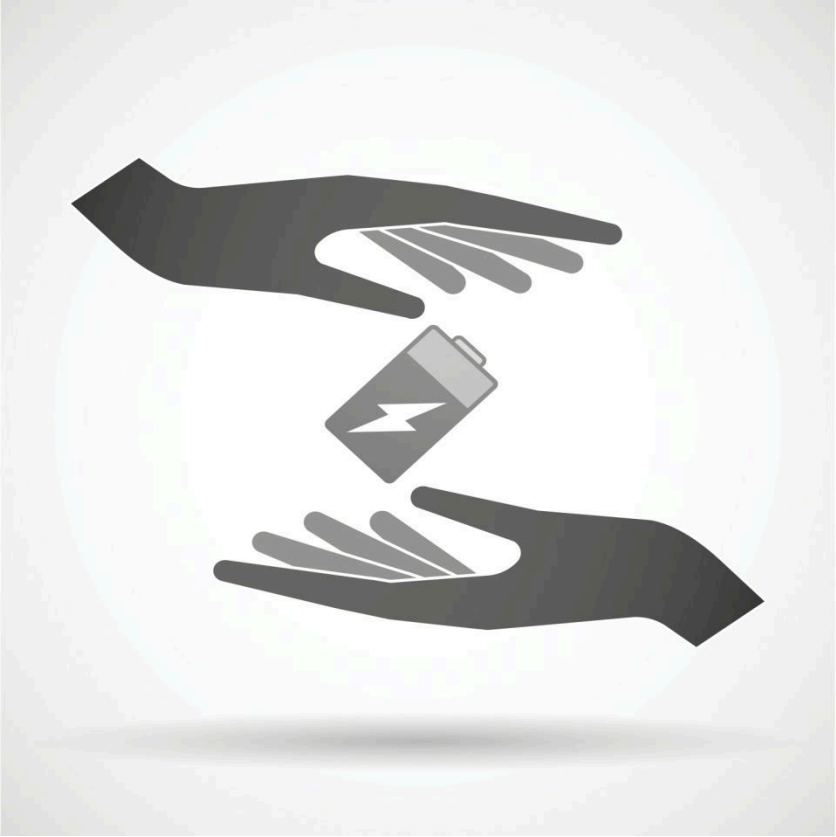
Many wearable devices for monitoring dietary intake have earlier suffered from limitations because they either had bulky wiring or needed a mouth guard or required frequent replacement because the sensors generally degraded. This new sensor is a breeze design wise, however it can also last only for a day or two after its worn. Though the authors state that redesign is progressing and in the future new models might be built which can stay active for a longer time in one's mouth. The future models could also be capable of detecting and recording a wide range of nutrients, chemicals and even physiological states of a person. The current sensor changes its colour based upon what nutrients or analytes are being sensed by it and this may not be so desirable. The most interesting aspect is that this sensor could very well be used anywhere else on another body part. It would only require some tweaking on which different chemicals to sense. So, technically it could be affixed to a tooth or skin or any other surface and it could still read and transmit information about its environment in real-time. However, the authors are also themselves unclear at this stage about what will be the exact cost of this sensor once its ready to buy and use and even that timeline is still not clear.

Source

Tseng et al. 2018, "Functional, RF-trilayer sensors for tooth-mounted, wireless monitoring of the oral cavity and food consumption" *Advanced Materials*, vol. 30, no. 18, DOI: 10.1002/adma.201703257

Use of nanowires to produce safer and powerful batteries

Study has discovered a way to make batteries that we use every day to be more resilient, powerful and safe



The year is 2018 and our everyday lives are now fuelled by different gadgets which either run on electricity or on batteries. Our reliance on battery-operated gadgets and devices is growing phenomenally. A battery is a device that stores chemical energy that gets converted into electricity. Batteries are like mini chemical reactors having reaction producing electrons full of energy which flow through the external device. Whether its cell phones or laptops or other even electric vehicles, batteries – generally lithium-ion – is the main power source for these technologies. As technology keeps advancing, there is continuous demand for more compact, high capacity, and safe rechargeable batteries.

Batteries have come a long way

Batteries have a long and glorious history. American scientist Benjamin Franklin first used the term "battery" in 1749 while performing experiments with electricity using a set of linked capacitors. Italian physicist Alessandro Volta invented the first battery in1800 when he stacked discs of copper (Cu) and zinc (Zn) separated by cloth soaked in salty water. The lead-acid battery, one of the most enduring and oldest rechargeable batteries was invented in 1859 and is still used in many devices even today including internal combustion engine in vehicles.

Batteries have come a long way and today they come in a range of sizes from large Megawatt sizes, so in theory they are able to store power from solar farms and light up mini cities or they could be as small as the ones used in electronic watches, marvellous isn't it. In a what is called a primary battery, reaction that produces the flow of electrons is irreversible and eventually when one of its reactants is consumed the battery becomes flat or dies. The most common primary battery is the zinc-carbon battery. These primary batteries were a big problem and the only way to tackle the disposing of such batteries was to find a method in which they could be reused – which means by making them rechargeable. Replacement of batteries with new one was obviously impractical and thus as the batteries became more powerful and big it became next to impossible not to mention quite expensive to replace them and dispose of them.

Nickel-cadmium battery (NiCd) was the first popular rechargeable batteries which used an alkali as an electrolyte. In 1989 nickel-metal hydrogen batteries (NiMH) were developed having longer life than NiCd batteries. However, they had some drawbacks, mainly that they were very sensitive to overcharging and overheating specially when they were charged say to their maximum rate. Therefore, they had to be charged slowly and carefully to avoid any damage and required longer times to get charged by simpler chargers.

Lithium-ion batteries – setting a benchmark

Invented in 1980, Lithium-ion batteries (LIBs) are the most commonly used batteries in consumer electronic devices today. Lithium is one of the lightest elements and it has one of the largest electrochemical potentials, therefore this combination is ideally suited for making batteries. In LIBs, lithium ions move between different electrodes through an electrolyte which is made of salt and organic solvents (in most traditional LIBs). Theoretically, lithium metal is the most electrically positive metal having very high capacity and is the best possible choice for batteries. When LIBs are underdoing recharging, the positively charged lithium ion becomes lithium metal.

Thus, LIBs are most popular rechargeable batteries for use in all kinds of portable devices owing to their long life and high capacity. However, one major problem is that the electrolyte can evaporate easily, causing a short-circuit in the battery and this can be a fire hazard. In practice, LIBs are really unstable and inefficient as over time the lithium dispositions become non-uniform. LIBs also have low charge and discharge rates and safety concerns make them unviable for many high power and high capacity machines, example electric and hybrid electric vehicles. LIB has been reported to exhibit good capacity and retention rates at very rare occasions.

Thus, all is not perfect in the world of batteries as in the recent years lot of batteries have been marked as unsafe because they catch fire, are unreliable and sometimes inefficient. Scientists worldwide are in

the quest of building batteries which will be small, safely rechargeable, lighter, more resilient and at the same time more powerful. Therefore, the focus has shifted to solid-state electrolytes as the potential alternative. Keeping this as the aim many options have been tried by scientists, but stability and scalability has been a hurdle of most of the studies. Polymer electrolytes have shown major potential because they are not only stable but also flexible and also inexpensive. Unfortunately, the main issue with such polymer electrolytes is their poor conductivity and mechanical properties.

New improved batteries by adding nanowires

In a recent study published in ACS *Nano Letters*, researchers have shown that a battery's safety and even many other properties can be enhanced by adding nanowires to it, making the battery superior. This team of researchers from College of Materials Science and Engineering, Zhejiang University of Technology, China have built upon their previous research where they made magnesium borate nanowires which exhibited good mechanical properties and conductivity. In the current study they checked if this would also be true for batteries when such nanowires are added to a solid-state polymer electrolyte. Solid-state electrolyte was mixed with 5, 10, 15 and 20 weight of magnesium borate nanowires. It was seen that the nanowires increased the conductivity of the solid-state polymer electrolyte which made the batteries more sturdy and resilient when compared to earlier without nanowires. This increase in conductivity was due to the increase in the number of ions passing and moving through the electrolyte and at a much faster rate.

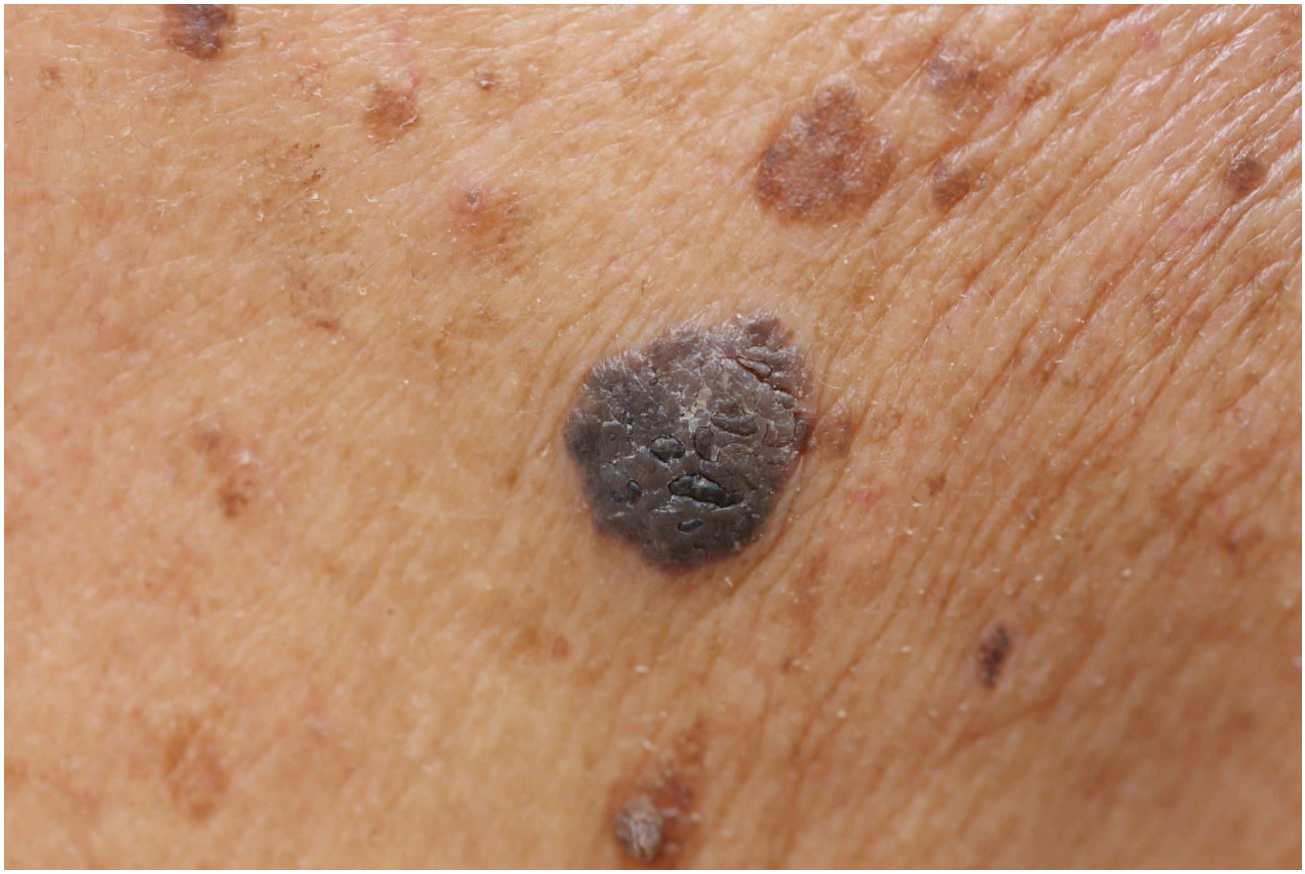
The entire set up was like a battery but with added nanowires. This showed a higher rate of performance and increased cycles compared to normal batteries. An important test of inflammability was also performed and it was seen that the battery did not burn. The widely used portable applications of today like mobile phones and laptops need to be upgraded with maximum and most compact stored energy. This obviously increases the risk of violent discharge and it is manageable for such devices because of the small format of batteries needed. But as larger applications of batteries are designed and tried, safety, durability and power assumes supreme importance.

Source

Ouwei Sheng et al. 2018, 'Mg2B2O5 Nanowire Enabled Multifunctional Solid-State Electrolytes with High Ionic Conductivity, Excellent Mechanical Properties, and Flame-Retardant Performance', *Nano Letters*, DOI: 10.1021/acs.nanolett.8b00659

Bacteria on healthy skin could prevent skin cancer?

Study has shown bacteria which is commonly found on our skin acts as a potential “layer” of protection against cancer



The occurrence of skin cancer has been steadily increasing over the past decades. Skin cancer is of two kinds – melanoma and non-melanoma. The most common type is the melanoma skin cancer which causes 2 and 3 million cases globally every year. The non- melanoma is not the most common type and affects 130,000 globally but is also serious because it can spread. One in every three cancers diagnosed

worldwide is a skin cancer. Our skin is the body's largest organ and is also the most important as it covers the entire body and protects us from harmful external factors like sun, abnormal temperatures, germs, dust etc. The skin is responsible for controlling our body temperature and remove sweat from our body. It makes the essential vitamin D and marvellously, the skin provides us with a sense of touch. The main cause of skin cancer is overexposure to the harmful rays of the sun. As the ozone layer in our atmosphere is gradually depleting the protective layer is going away leading to more UV(ultra-violet) radiation of the sun to each the earth's surface. Melanoma cancer, which starts in pigment-producing skin cells, is caused by abnormal changes in the skin when cancerous cells start growing and the main factor is somehow connected with an individual's exposure to the sun and their history of sunburn. Non-melanoma skin cancer starts in the cells of the skin and grows out to destroy nearby tissue. This type of cancer generally does not spread to other parts of the body (metastasize) but melanoma cancer does.

Healthy bacteria on skin to "protect" against skin cancer

In a recent study published in *Science Advances*, researchers have described a new potential role of the bacteria on our skin in protecting us against cancer. Researchers at UC San Diego School of Medicine, USA have identified a strain of the bacteria Staphylococcus epidermidis which is very commonly found on healthy human skin. This unique strain of skin bacteria is seen to inhibit growth (kill) of several types of cancers by producing a chemical compound - 6-N-hydroxyaminopurine (6-HAP) in mice. It was clear that only the mice which had this bacterial strain on their skin and thus made 6-HAP did not have skin tumours after they were exposed to cancer causing UV rays. The chemical molecule 6-HAP basically impairs the synthesis (creation) of DNA thereby preventing the spread of tumour cells and also suppressing the development of new skin tumours. The mice were injected with 6-HAP every 48 hours over a period of two weeks. The strain is non-toxic and does not affect the normal healthy cells while reducing the already present tumours by almost 50 percent. The authors state that the bacterial strain is adding "another layer" of protection to our skin against cancer.

This study clearly shows that our "skin microbiome" is an important aspect of the protection which skin offers. Some skin bacteria are already known for producing antimicrobial peptides which protect our skin from invasions by pathogenic bacteria. Further studies are required to understand the workings of 6-HAP and whether ideally it could be used as a preventative measure against cancer.

Source

Nakatsuji, T. 2018, 'A commensal strain of Staphylococcus epidermidis protects against skin neoplasia', *Science Advances*, vol. 4, no. 2, eaao4502, DOI: 10.1126/sciadv.aao4502

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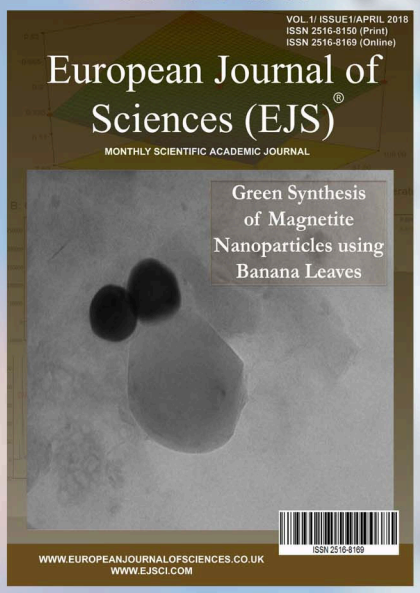

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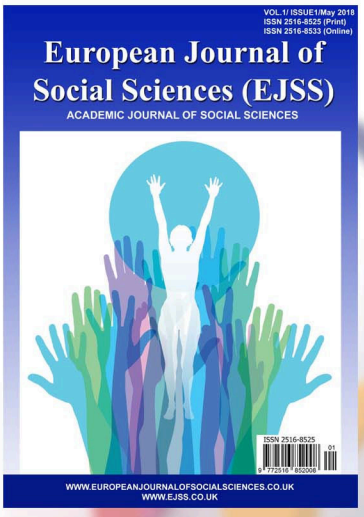

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