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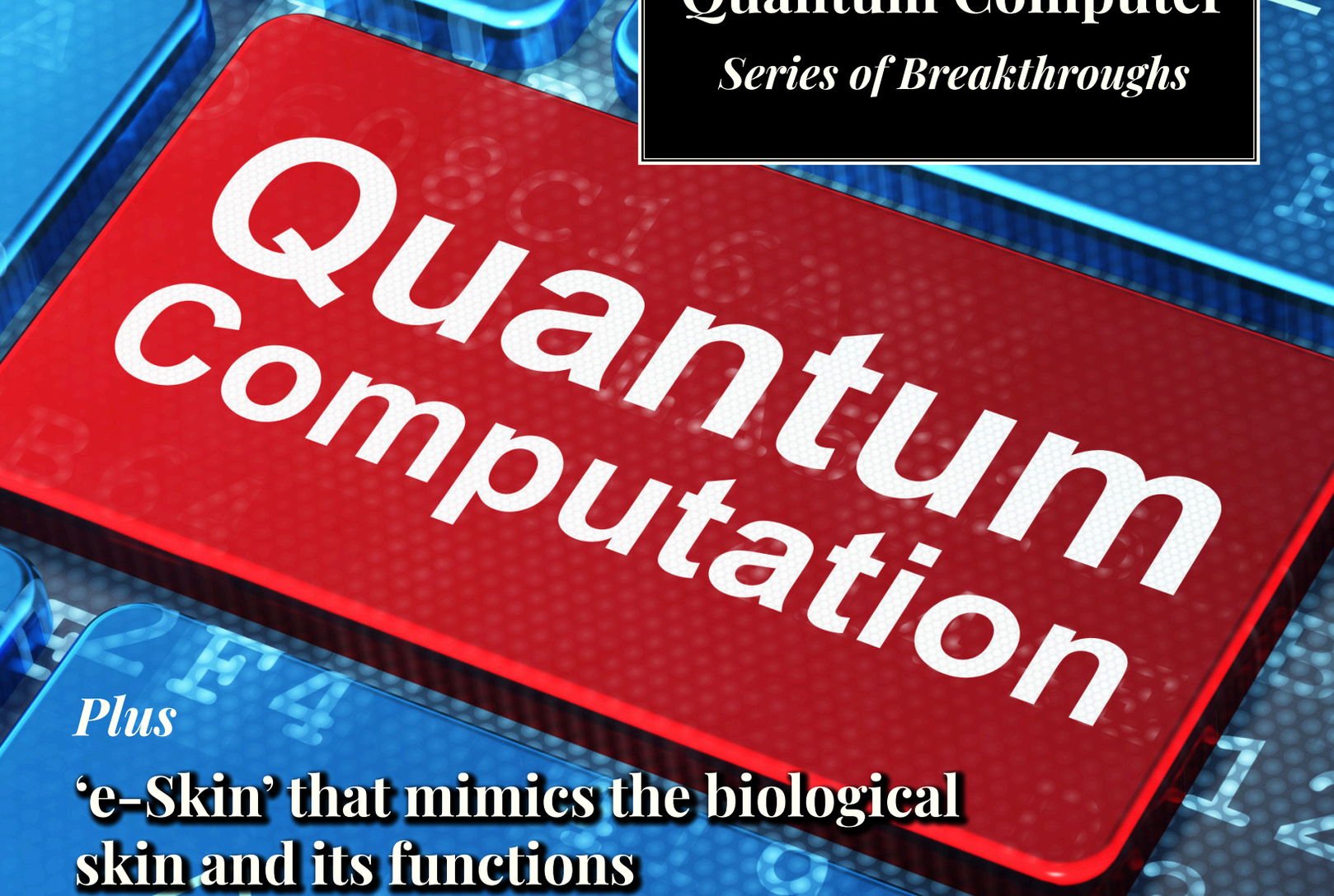

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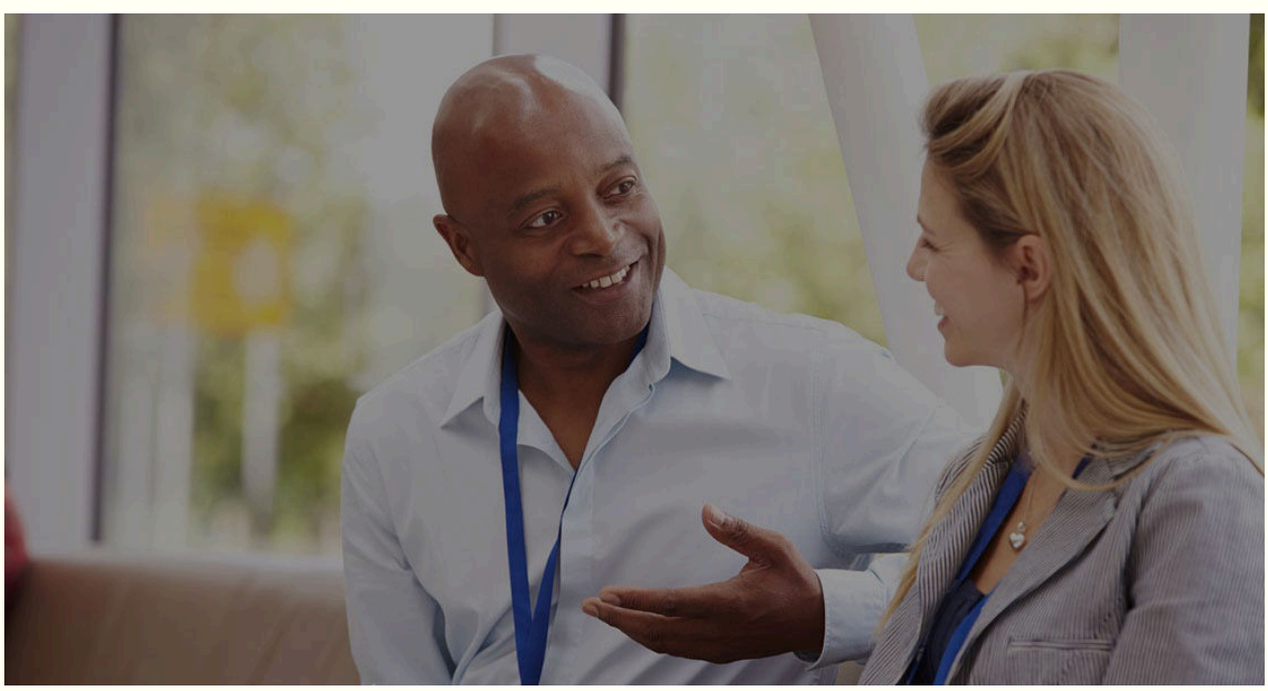

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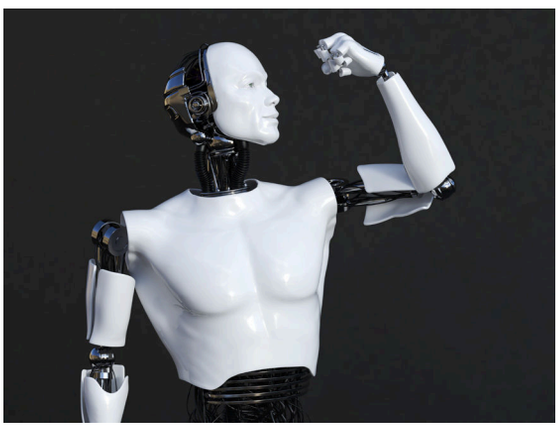

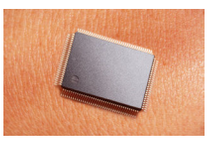

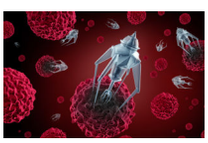

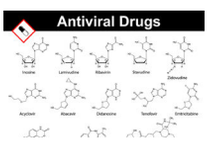

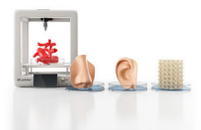

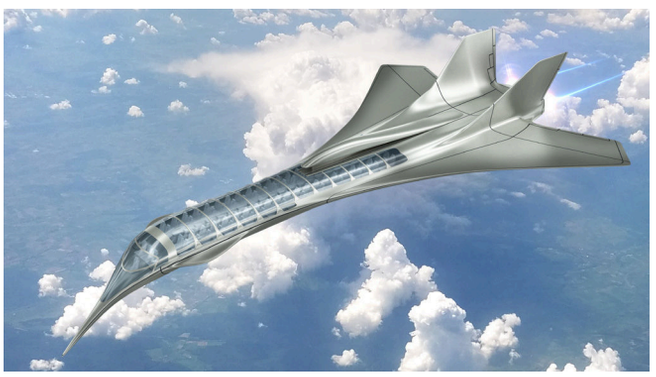

NOTE FROM THE FOUNDER & EDITOR-IN-CHIEF

We are delighted to bring nine articles on latest scientific breakthroughs that hold great promises to the mankind – Quantum computing, e- Skin, new blood test for cancer screening, artificial muscle, advances in understanding of schizophrenia and many more.

Hope you enjoy reading them.

Doing our bit in disseminating latest scientific information to the wider audience.

Umesh Prasad

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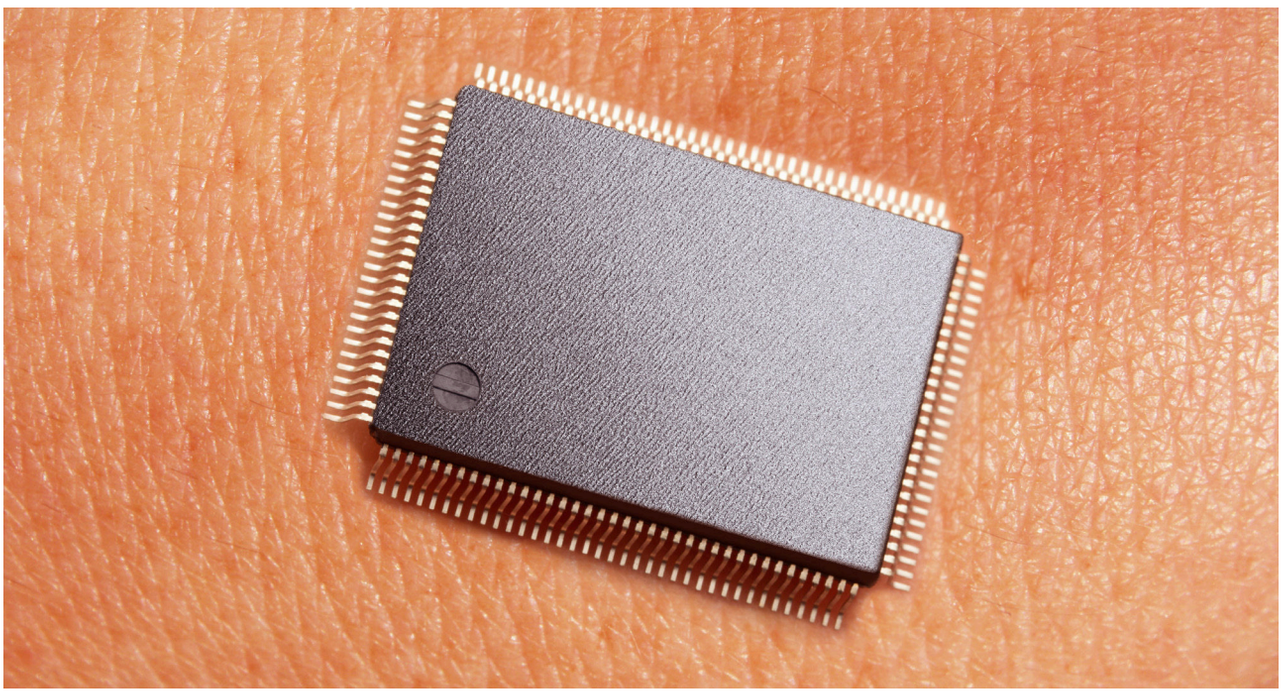
‘e-Skin’ that Mimics the Biological Skin and its Functions



The discovery of a new type of malleable, self-healing and completely recyclable “electronic skin” has wide applications from health monitoring, robotics, prosthetics and improved biomedical devices.

A study published in Science Advances showcases a new electronic skin (or simply e-skin) that has multitude of properties including malleability, self-healing and full recyclability when compared to the human skin[1]. The skin, our largest organ, is the fleshy covering when seen from outside. Our skin is a highly versatile organ which acts as a waterproof, insulating shield and guards our body from a variety of external dangers or factors e.g. damaging sun.Some of the functions of skin is regulationof body temperature, protection of body from intake of toxic substances and also excretion of toxic substances (along with sweat), mechanical and immunological support and production of the crucial vitamin D which is very important for our bones. Skin is also a huge sensor with ample nerves to instantly communicate with the brain.

Researchers worldwide have been working on developing a number of different types and sizes of ‘wearable e-skins’ with the ultimate goal of trying to mimic the biological skin and its various functions. There is a strong need for flexible and stretchable devices for the seamless integration with soft and curvilinear human skin. Nanoscale (10^{-9}m) materials can provide the required mechanical and electrical versatility replacing the rigid silicon which hasusually used before. The team led by Dr. Jianliang Xiao at the University of Colorado, Boulder, USA, have successfully

developed an artificial electronic skin (e-skin) with the goal of translating the sensory touch of the human skin onto robots and prosthetics. This attempt is in the direction of having a "wearable" technology in the future which would have huge potential and value in medical, scientific and engineering fields.

E-skin: self-healing and recyclable

E-skin is a thin, translucent material having a novel type of covalently bonded dynamic polymer network, called polyimine, which is laced with silver nanoparticles for improved mechanical strength, chemical stability and electrical conductivity. This e-skin also has sensors embedded in it to measure pressure, temperature, humidity and air flow. This e-skin is being considered remarkable because it has been incorporated with many features which make it an extremely closer mimic of the human skin. It is highly malleable and can be easily set onto curved surfaces (e.g. human arms and legs, robotic hands) by applying moderate heat and pressure to it without introducing excessive stresses. Further, this e-skin has amazing self-healing properties wherein upon any cut or damage caused by an external circumstance, the e-skin recreates the chemical bonds between the two separated sides, restoring the matrix for its proper functionality and returning to its original bonded state.

Also, if this e-skin becomes unusable due to any circumstance, it can be completed recycled and basically turned into a brand-new e-skin, by placing it in a recycling solutionthat "liquifies" the existing e-skin material, thereby turning it into a "new" e-skin. This recycling solution, which is a mixture of three commercially available chemical compoundsin ethanol, degrades the polymers and the silver nanoparticles sink at the bottom of the solution. These degraded polymers can be used afresh to make a new, functional e-skin. This self-healing and recyclability which is attainable at room temperature is mainly attributed to the chemical bonding of the polymer used.The advantage of this polymeric network of polyimine is that its reversible and can be broken and recycled unlike most conventional thermostat materials which can neither be reshaped or reprocessed or recycled because of the irreversible bonds within their cross-linked polymeric networks. Thus, its actually more robust than human skin itself and it could be used as an enhancement to it rather than replacement. It is also pleasant to touch and feels almost like real skin which could possibly make it as the covering agent in the future, of say electronic devices maybe.

These eco-friendly and low on cost properties of the e-skin have been hailed and such e-skin could greatly reduce electronic waste and the environmental impact and also could be highly usable and popular with manufacturers in different fields. Though it may sound farfetched at the moment, this reuse technology could also be similarly applied to old electronics items as well. In fact, modern dayfitness trackers and health monitorsupon getting damaged, add to the growing mountain of e-waste compounding environment related problems. This e-skin could be worn around our necks or on our wrists and these could be like flexible wearables or temporary tattoos and whenever they get damaged, they can just be recycled and reused. And since e-skin is flexible, it can be bent and twisted and can be made customized according to the wearer. Thus, this technology opens up avenues for intelligent robotics in which sucha pleasant to feel and conformable electronic skin can be wrapped around the body of a robot or an artificial limb. To elaborate, a prosthetic arm or leg which is wrapped in this electronic skin can allow the wearer to respond to temperature and pressure changes because of the multiple sensors incorporated in it. And also, the robotics arms or legs fitted with such an e-skin can make the robots act more delicately towards humans and be more safe and reliable. For example, the e-skin could be specifically fitted to a robot handling a baby or a fragile elderly and thus robot will not be applying too much force. Another application of e-skin can be potentially in hazardous environments or high-risk jobs. It is plausible that this technology could be used with virtual buttons, controls, or doors that would enable any operation without humanphysical interaction, for example in explosives industry or other dangerous lines of work, and thus this e-skin maybe able to decrease the chances of any human injury.

Adding display to e-skin

A team of researchers at University of Tokyo have recently added a display[2] (micro-LED) to ultrathin, band aid-style e-skin patches to enable display of different signs of health monitoring in real time (e.g. measuring glucose levels in people with diabetes or the moving waveform of an electrocardiogram of a heart patient). These patches have a stretchable wiring and thus can bend or stretch to up to 45% based upon the movement of the wearer. These are considered as having the most flexible and durable design in recent times. The continuous shedding of human skin cells could mean that the patch might fall off after a few days but this can be worked around with believe the researchers.

This study, led by Professor Takao Someya states that such a display can be eventually used to enablereading and communicatingmedical information in a seamless and easy mannernot only for patients but also for family members, care givers and health professionals either in person or even remotely.Also, it would receive messages as well. The researchers aim to further improve the reliability of the patch,make it more cost effective and also increase its production for a wider reach around the globe. Their goal is to launch this device in the market by the end of 2020.

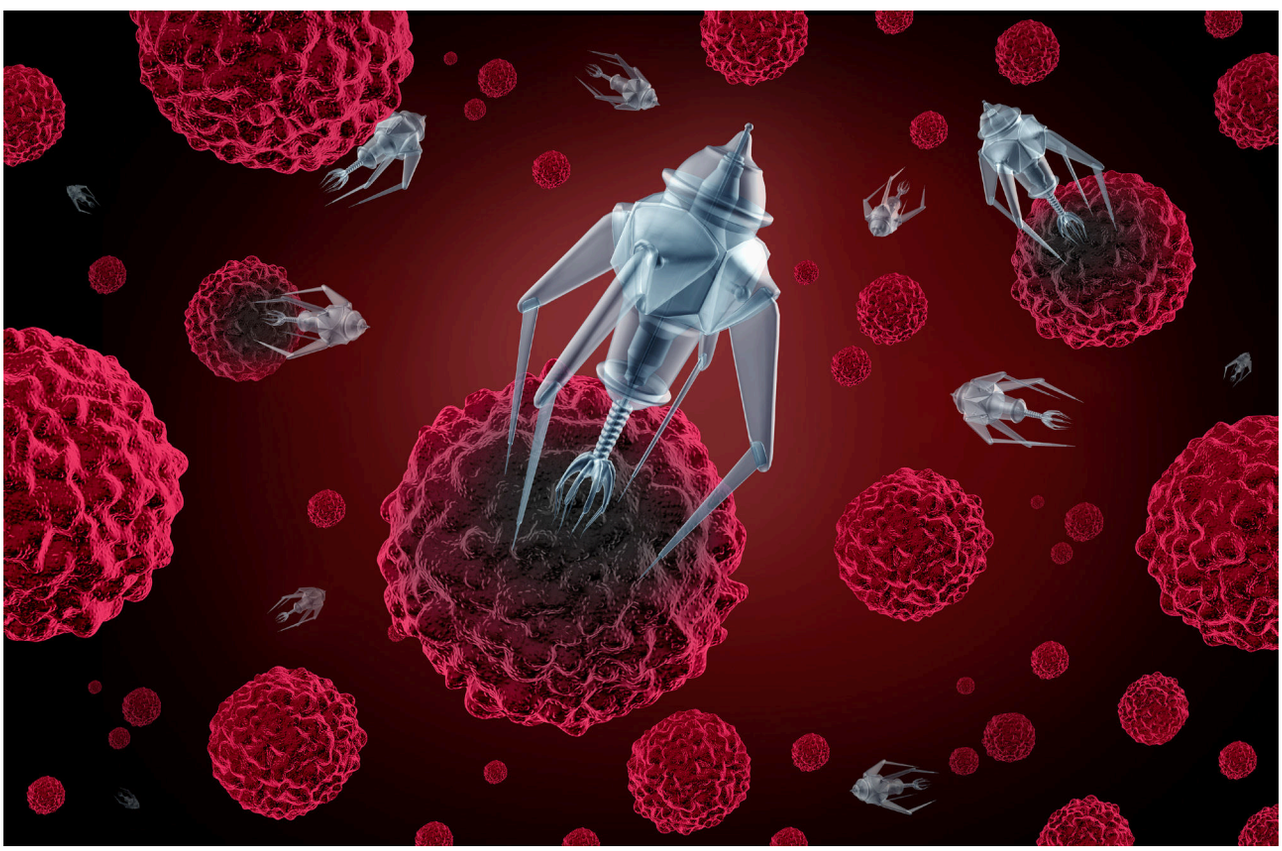
Challenges ahead

The development of e-skin is a very exciting novel research, however, one of the fundamental properties of our - flexibility and stretch ability - is yet to be successfully achieved by the e-skin. This e-skin is definitely soft but not as stretchy as human skin. Also, according to the authors, as it stands the material is also not very easily reproducible. The researchers also point out that they observed a slight reduction in the overall sensing performance in a rehealed/recycled e-skin device compared to a fresh module, this needs to fully addressed with further research. The magnetic fields used by these e-skins are also quite high and need to be scaled down. Also, currently the device is powered from an external source which is very impractical, but it should be possible to have rechargeable, small batteries to power the device instead. Dr. Xiao and his team want to refine this product and improve the scaling solution so that at least the economic hurdles can be surpassed and this e-skin should be easier to manufacture and place on robots or prosthetics or medical devices or anything else.

Source:

1. Zou, Z., Zhu, C., Li, Y., Lei, X., Zhang, W., Xiao, J. 2018, 'Rehealable, fully recyclable, and malleable electronic skin enabled by dynamic covalent thermoset nanocomposite', *Science Advances*, DOI: 10.1126/sciadv.aaq0508
2. Someya, T. 'Continuous Health-Monitoring With Ultra flexible On-Skin Sensors', 2018 AAAS Annual Meeting Symposium, Austin, Texas, February 17, 2018.

Nanorobotics – A Smarter and Targeted Way to Attack Cancer



In a recent study, researchers have developed for the first time a fully autonomous nanorobotic system for specifically targeting cancer.

In a major advancement in nanomedicine, the field that combines nanotechnology with medicine, researchers have developed novel avenues of therapeutic treatment using very small, molecule-sized nanoparticles (machine or robots which are close to the microscopic scale of a nanometer 10^{-9} m) to target cancer, in this remarkable study published in *Nature Biotechnology*.

DNA origami nanobot: the magic transporter

DNA origami is a process in which a DNA is folded in a nanoscale level and is used to build active structures at the tiniest scales (origami as in the art of paper folding). DNA is a great storage of information and thus structures which are built out of it can be used as information carriers. In line with this capability, these DNA nanoparticles (or 'DNA nanorobots' or 'nanorobots' or simply 'nanobots') can move and lift cargo at the smallest scales for specific tasks in the human body and thus are suitable for many nanorobotic applications.The size of such a nanobot is 1000 times

smaller than a single strand of human hair. This field of nanorobotics has been full of excitement for the past two decades and many experts have been focusing on developing such nanoscale structures based out on DNA which can fold themselves into all sorts of shapes and sizes to revolutionize medicine especially therapy and drug delivery.

Nanorobot technology is now being widely used and has already revolutionised fields like medical imaging, devices, sensors, energy systems and also medicine. In medicine, nanobotshave significant advantages mainly because they do not generate any harmful activities, have no possible side effect and are are very specific in which site in the body will they target and operate on. The initial cost of development of nanorobots maybe high but the manufacturing when done by the conventional method of batch processing reduces the cost to a great extent.Further, the miniscule size of the nanorobots make them ideal for targeting bacteria and viruses. Also, a tiny nanorobot can be injected very easily into the body and it easily floats through the blood (the circulatory system)and helps in detecting the problems and treating them.Nanobots have gained a lot of significance in cancer research since they can be a painless alternative of chemotherapy which is otherwise very stressful and puts a huge personal and financial burden on the patient. Chemotherapy is not only aharsh way of treating cancer, but aside from attacking the cancer cells, the procedure leaves several side effects throughout the body. Yet science has not been able to discover any new alternative to chemotherapy for treating this life-threatening disease called cancer. Nanobots have the potential to change this scenario in the coming years by being a more efficient, smarter and targeted alternative attacking cancer.

Targeting cancer

In this recent study, a collaboration between Arizona State University, USA,and National Centre for Nanoscience and Technology of the Chinese Academy of Sciences, Beijing, researchers have successfully designed, built and carefully controlled automated nanobots to actively seek and precisely destroy cancerous tumours inside the body – while not harming any of the healthy cells. They overcame several challenges that have been plaguing nanoscientists for over two decades, by designing and using a very simple and straightforward strategy to seek and destroy the tumour. The strategy was to specifically cut-off the blood supply in a tumour cell by inducing blood coagulation into the tumour cell using DNA-based nanobots. So, they thought of something seemingly simple – attach a key blood-clotting enzyme (called Thrombin) to the surface of the flat, nanoscaled DNA origami nanobot. An average four molecules of Thrombin were attached to the flat surface of the DNA origami sheet of size 90nm by 60nm. This flat sheet was folded like a sheet of paper making the nanobots mould into the shape of a hollow tube. These nanobots were injected into a mouse (which had been induced with aggressive tumour growth), theytravelled throughout the bloodstream reaching and binding to its target - the tumours.Subsequently, nanobot's cargo - enzyme Thrombin - gets delivered thereby blocking the tumour blood flow leading to clotting of blood within the vessels which feed tumour growth, generatingthe destruction of the tumour tissue or cell death. This entire process, interestingly happens very swiftly and the nanobots surround the tumour within hours of the injection. Evidence of advanced thrombosis, in all tumour cells was observed after 36 hours of injection.

Further, the authors also took care of including a special payload on the surface of the nanobot (called a DNA aptamer) which would specifically target a protein, called nucleolin, which is made in high amounts only on the surface of tumour cells, thus reducing the chances of nanobots ever attacking the healthy cells to zero.These nanobots not only reduced and killed the tumour cells but also prevented metastasis – secondary cancerous growth at a distant site.

Safety and effectiveness

The authors stress that nanobots are safe and immunologically inert for use in mice and even pigs and the use of nanobots showed no changes in normal blood coagulation elsewhere or cell structure or any breech into the brain. Thus, they have been designated as safe and effective

towards targeting and shrinking tumours without anypossible unwanted side effects. Most of the nanobots were also seen to be degrading and clearing from the body after 24 hours. Though the nanobots could be designed in a 'replicating nanobots'model, which is understandable to keep the costs down as a few copies are made and other nanobots are self-generated, it is clear that such an approach should only be applied in special circumstances. As far as the field of medicine is concerned,a foolproof kill-switchalso needs to be in place so as to keep any extreme circumstances at bay.Legal authorities need to devise regulations to avoid any misuse of nanobots in medicine, for example weaponized nanobots. All the factors when weighed in, the efficacy of nanobots brings us to a point that they cannot be overlooked and looking at their potential nanobots will be an essential component of medicine in the future.

A similar approach could be used on humans as the authors have shown that this system was also tested on a primary mouse lung cancer model - which mimics the human clinical course of lung cancer patients- and showed regression oftumour after a two-week treatment. Also, these studies were conducted on mice, and within two weeks a similar demonstrable effect on breast cancers, melanoma, ovarian and lung cancer was seen in the animals. The study, however needs to be done in humans to confirm the plausibility of similar results and robust clinical trials needs to be carried out for achieving the same.

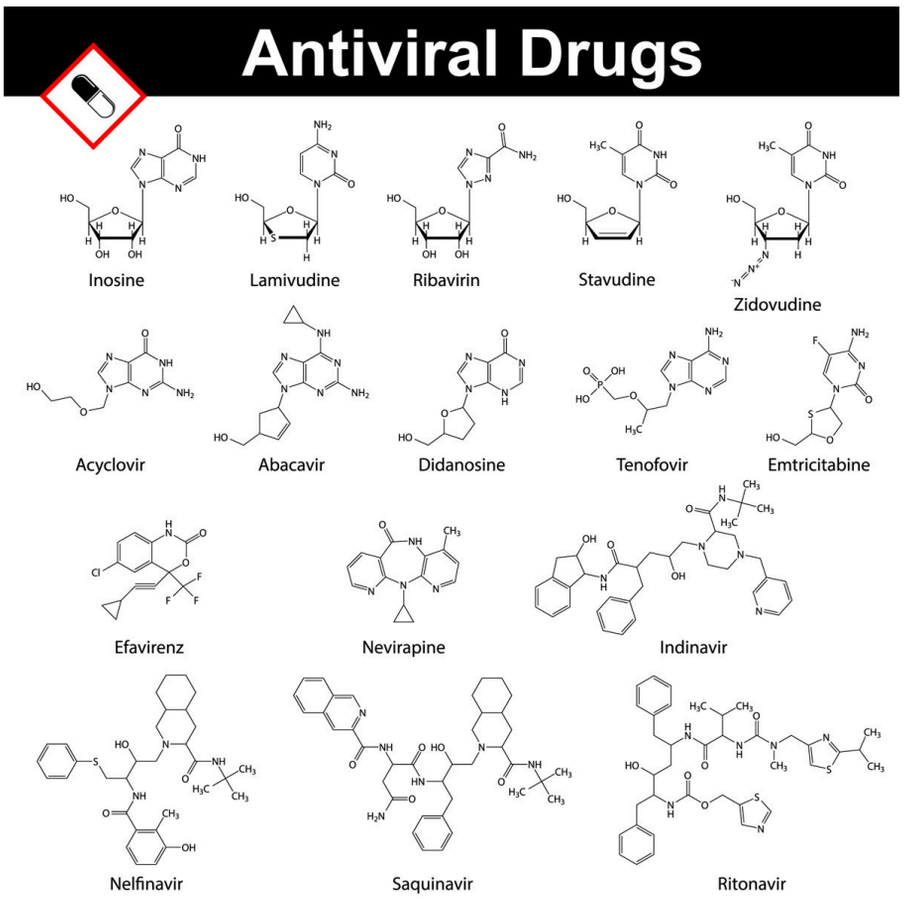
A very smart and targeted way to attack cancer

One of the major challenges of cancer therapeutics is to carefully and correctly differentiate between the cancer tumour cells and the normal, healthy body cells. The conventional approach to shirking and killing tumour cells – chemotherapy and radiation therapy– fails to target the tumour cells selectively without interacting with the normal body cells. Thus,chemotherapy and also radiation therapy tend to cause serious side effects, both minor and major, including organ damage which results in a very impaired treatment of cancer and thus low survival rates among patients. Nanobots such as the ones described in this study are first-of-its-kind in mammals that are very strong and effective in identifying tumour cells and diminishing their growth and proliferation. This DNA robotic system can be used for precise and targeted cancer therapy for many types of cancer, since all solid tumour feeding blood vessels are essentially same.

This research has paved the way for future to start thinking and planning practical medical solutions using technological advances. The ultimate goal of cancer research is the successful eradication of solid tumours, with no grave side-effects and reduced metastasis. Looking at this study, we see immense hope for the future where this current strategy could be ideal for accomplishing the ultimate goal to tackle cancer. And not only cancer, this strategy could also be developed as a drug delivery platform for treatment of many other diseases too because the approach would be simply modifying the structure of nanobots and altering loaded cargos. Also, nanobots can help us to further understand the complexity of the human body and brain. This will also help in performing painless and non-invasive surgeries, even the most complicated ones.Hypothetically at this point, owing to their size nanobots could also surf through the brain cells and generate all the related information required for further research. In future, let's say two decades from now, a single injection of a nanobot might be able to completely cure diseases.

Source
Li., S. et al. 2018, 'A DNA nanorobot functions as a cancer therapeutic in response to a molecular trigger in vivo'. Nature Biotechnology, DOI: 10.1038/nbt.4071

A Broad-Spectrum Antiviral Drug... Finally!



Recent study has developed a new potential broad-spectrum drug for treating infections from Herpes Simplex Virus-1 and possibly other viruses in both new patients and who have got drug resistance from available drugs.

The traditional therapeutic approach in medicine has always followed the 'one-bug-one-drug' paradigm, also sometimes called as 'many for one' in which a drug (or drugs) targets only one particular disease-causing organism in the body. Scientists and researchers worldwide are now moving away from this paradigm and adopting the alternative 'one for many' approach, specially in the case of antibiotics and also now antivirals. Broad-spectrum medicines are being developed which generally target multiple or all disease-causing organisms. For example, many broad-spectrum antibiotics are available today which act against a wide range of disease-causing bacteria (anti-bacterial antibiotics) and fungi (anti-fungal antibiotics). Such broad-spectrum antibiotics are very powerful and flexible drugs that can not only be used against wide variety of bacteria but can also be used to treat bacterial infections for which the causing bacteria is not known or identified yet. The most common, popular broad-spectrum antibiotic is the Ampicillin which can attack a variety of bacterial strains.

Similar to such antibiotics, broad-spectrum antiviral drugs will have a strategy to target different types of viruses. In adopting this approach for antivirals, researchers need to first identify the various characteristics of the host that viruses 'depend on' for their lifecycle. It is here that viruses are profoundly different from bacteria and since viruses hijack our (we are the host) cellular machinery, it is obviously much difficult to disrupt viral growth without causing disruption in a human cell function. But since a variety of viruses take advantage of the 'same host function', an antiviral drug can basically deprive the virus from any access to the host function. The underlying idea is to 'stop' one happening in the host which is enabling the virus to grow. This said, it should then be possible to design a broad-spectrum antiviral drug which 'deprives' and thus kills the virus, no matter which virus it is. Many narrow-spectrum antivirals have failed over the years because viruses are so different from bacteria, they also mutate much faster and any narrow-spectrum antiviral drug which is developed after years of labour generally has a very limited shelf life and anyway such antivirals have a very narrow scope of attack to begin with because they attack only a particular virus. As of 2018, we still don't have any medication for so many nasty viruses, e.g. Ebola. Thus, we really need a strong, safe, viable wide-spectrum antiviral which can target only a host mechanism and thus will be able to deprive and kill a variety of viruses. In a recent breakthrough study, researchers have identified a mechanism in the host which if targeted can result in deprivation and killing of herpes simplex virus 1 and this same broad-spectrum therapeutic could be potentially applied to other viruses as well.

An estimated two-thirds of the world's population who is under 50 years of age is infected by herpes simplex virus type 1 (HSV-1), which makes it to be more than 3.7 billion people worldwide, according to World Health Organization (WHO). Thus, HSV-1 is a very common contagious viral infection which is endemic throughout the world. The HSV-1 infection persists for a lifetime even if it is acquired during childhood or adolescence. This virus infects primarily the mouth and eyes but sometimes also genitalia. Like most viral infections, it spreads very easily and it is extremely challenging to prevent it. The handful of treatment drugs available for these infections are successful to a large extent, however the virus has emerged with drug-resistant strains especially after long-term use because most of these drugs follow a similar therapy approach. Thus, there is an urgent need to explore new and effective tactics to circumvent drug resistance to HSV.

New therapy for HSV-1 infection

Infection in the eye can be temporarily eliminated using available antiviral drugs but inflammation in the cornea – outer layer of the eye ball – is seen to persist indefinitely leading to other conditions like glaucoma and blindness by overuse of steroids medication. The current drugs in the market, called nucleoside analogues, basically prevent the virus from producing a protein which is crucial for virus's replication and growth. However, drug resistance is an important aspect and patients who develop resistance to these analogues are left with very limited options to treat HSV-1 infection. In a major recent study, published in *Science Translational Medicine*, researchers have identified a small drug molecule which clears the HSV-1 infection in the cells of the cornea and works very differently than the drugs that are available making it a promising alternative potential drug against HSV-1.

The authors have reported that this small drug molecule – called BX795 – clears the infection in human corneal cells (cultured in the laboratory) and also corneas of infected mice. This drug molecule follows a very novel way in which it acts on the host cells (instead of the infection, which is generally what the current drugs do) to clear up the viral infection. This molecule is an already known inhibitor of an enzyme TBK1 which is involved in immunity in the host, or more specifically in innate immunity and neuroinflammation. Innate immunity or our 'in-born immunity system' comprises of cells and mechanisms that defend us from infection by other organisms. Also, it has been established before that partial TBK1 deficiency results in neuroinflammatory or neurodegenerative disorders. In this study, when this enzyme gets suppressed (by adding TBK1), the viral infection was seen to be growing. However, quite unexpectedly and on the contrary, higher concentrations of BX795 was on the other hand clearing up the HSV-1 infection in cells.

Though overall, lower concentrations of this molecule were required to clear the infection when compared to current drugs nucleoside analogues. No toxicity or any other effects were visible in the uninfected cells at these therapeutic concentrations. The authors do state here that a topical version of the dosage was used in the studies, though they are also in the midst of formulating a similar oral dosage.

Can BX795 be used to target other viral infections?

As this particular study this molecule only worked on the cells that were infected with HSV-1. The obvious question to ponder upon is whether a similar therapeutic approach can be applied to other critical viral infections like HSV-2 (herpes simplex virus 2) or even HIV (human immunodeficiency virus). The authors point out that since most viruses follow a common pathway to replicate inside a host cell, and BX795 targets that pathway, this can definitely be a new kind of broad-spectrum antiviral which could be used to treat other viral infections as well and could fill the gap that exists in the field of broad-spectrum antiviral drugs. For example, the novel mechanism of this drug where it targets the host cells should work on inhibiting HIV infections. And, Human Papillomavirus (HPV) infections could be possibly targeted in a similar way by blocking a process called AKT phosphorylation in the host cells which is essential for HPV to propagate. The authors are looking at having human clinical trials soon for this new drug molecule and since it has shown low toxicity, it can be a great potential for systemic use and also topical application.

However, the broad-spectrum aspect of these antivirals needs to be taken with caution since it is widely reported that they might cause other problems in the body, like risk of immune system deregulation and also enhanced toxicity in the cells. The proper dosage of such a drug also needs to be decided with care. Further, translating the laboratory studies successfully to testing in animals (e.g. mice) is also crucial. Sometimes our immune system will attack antiviral drugs assuming that drug to be an invader instead, because the antiviral is technically aiming to 'target' a host mechanism. Also, the whole process of 'laboratory to animal testing to human testing' is loaded with potential failures for such antivirals because sometimes drugs that work in mice are totally useless in humans. Our body is filled with beneficial viruses too (trillions maybe) which may actually be essential to our health, including some microbe-infecting viruses and a wide-spectrum antiviral might deprive these good viruses too and killing them which is not an ideal scenario that we desire. It is no doubt that alternative broad-spectrum antivirals are definitely required as drug resistance is becoming a global problem and we don't even have drugs for so many viruses. This discovery looks promising for new patients as well as for patients who have developed resistance against the available drugs. Also, such an antiviral drug could be used to target multiple viruses, which can lead to breakthroughs. Further steps are to be taken in the direction of establishing the accurate potential of this new drug molecule and the authors hope for a topical version of this drug within the next three years.

Source: Jaishankar et al., 2018, 'An off-target effect of BX795 blocks herpes simplex virus type 1 infection of the eye', *Science Translational Medicine*, vol. 10, no. 428, eaan5861, DOI: 10.1126/scitranslmed.aan5861

Constructing 'Real' Biological Structures Using 3D Bioprinting

In a major advancement in 3D bioprinting technique, cells and tissues have been created to behave like in their natural environment so as to construct 'real' biological structures.

Constructing 'real' biological structures using 3D Bioprinting In a major advancement in 3D bioprinting technique, cells and tissues have been created to behave like in their natural environment so as to construct 'real' biological structures 3D printing is a procedure in which a material is added together and thus joined or solidified under digital control of a computer to create a three-dimensional object or entity. Rapid Prototyping and Additive Manufacturing are the other terms used to describe this technique of creation of complex objects or entities by layering material and gradual built up – or simply an 'additive' method. This remarkable technology though has been around for three decades after being officially discovered in 1987, it has recently been thrusted into limelight and popularity as not just being a means of producing prototypes but rather offering full-fledged functional components. Such is the potential of possibilities of 3D printing that it is now driving major innovations in many areas including engineering, manufacturing and medicine.

Different types of additive manufacturing methods are available which follow the same steps to achieve the final end result. In the first crucial step, design is created using CAD (Computer-Aided-Design) software on computer – called a digital blueprint. This software can predict how

the final structure will turn out and also behave, thus this first step is vital for a good result. This CAD design is then converted into a technical format (called a .stl file or standard tessellation language) which is required for the 3D printer to be able to interpret the instructions of design. Next, the 3D printer needs to be set up (similar to a regular, home or office 2D printer) for the actual printing – this includes configuring the size and orientation, opting for landscape or portrait prints, filling up the printer cartridges with the right powder. The 3D printer then starts the printing process, gradually building up the design one microscopic layer of the material at a time. This layer is typically around 0.1mm in thickness though it can be customized to suit a particular object being printed. The entire procedure is mostly automated and no physical intervention is required, only periodic checks to ensure correct functionality. A particular object takes several hours to days to complete, depending on the size and complexity of the design. Further, since it's an 'additive' methodology, it is economical, eco-friendly (with no wastage) and also provides much greater scope for designs.

The next level: 3D Bioprinting

Bioprinting is an extension of traditional 3D printing with the recent advancements have enabled 3D printing to be applied to biological living materials. While 3D inkjet printing is already being used to develop and manufacture advanced medical devices and tools, a step further needs to be developed to print, view and understand biological molecules. The crucial difference being that unlike the inkjet printing, bioprinting is based on bio-ink, which is comprised of living cell structures. So, in bioprinting, when a particular digital model is input, the specific living tissue is printed and built up layer by cell layer. Because of the highly complex cellular components of the living body, 3D bioprinting is progressing slower and complexities such as the choice of materials, cells, factors, tissues are posing additional procedural challenges. These complexities can be tried to be addressed by broadening the understanding by integrating technologies from interdisciplinary fields e.g. biology, physics and medicine.

Major progress in bioprinting

In a recent study published in *Advanced Functional Materials*, researchers have developed a 3D bioprinting technique which uses cells and molecules normally found in natural tissues (their native environment) to create constructs or designs that resemble 'real' biological structures. This particular bioprinting technique combines 'molecular self-assembly' with '3D printing' to create the complex biomolecular structures. Molecular self-assembly is a process by which molecules adopt a defined arrangement on their own to perform a specific task. So, in a real sense, this technique integrates the 'micro- and macroscopic control of structural features' that '3D printing' provides with the 'molecular and nano-scale control' enabled by the 'molecular self-assembly'. That is, it uses the power of molecular self-assembly to stimulate the cells that are being printed, which is otherwise a limitation in 3D printing when the regular '3D printing ink' does not provide this means for this.

The researchers 'embedded' the structures in 'bio ink' which is similar to their native environment inside the body making the structures essentially behave as they would in the body. This bio-ink, also called the self-assembling ink basically helps to control or modulate the chemical and physical properties during and after the printing, which then allows to stimulate cell behaviour accordingly. This unique mechanism when applied to bioprinting allows us to make observations on how these cells work within their environments, thereby giving us a snapshot and understanding of real biological scenarios. In essentiality, it raises the possibility of building 3D biological structures by printing multiple types of biomolecules capable of assembling into well-defined structures at multiple scales.

The future is very hopeful!

To say that 3D bioprinting can bring about some hope in medicine and healthcare is simply undermining its powers. It is the ultimate hope for the future as so many different possibilities can be achieved through this amazing technology. Firstly, bioprinting research is already being used to generate different types of tissue and thus can be very important for tissue engineering and regenerative medicine to address the need for tissues and organs suitable for transplantation - skin, bone, grafts, heart tissue etc. Further, the technique described opens up a wide array of possibilities to design and create biological scenarios like complex and specific cell environments to enable prosperity of tissue engineering by actually creating objects or constructs -under digital control and with molecular precision- which resemble or mimic tissues in the body ('in vitro' or in laboratory). The living tissue, bone, blood vessels and, potentially, whole organs models for medical procedures, training and testing and also for research and drug discovery initiatives are possible to create. Very specific and generation of customized patient-specific constructs can help in designing accurate, targeted and personalised treatments.

One of the biggest obstacles for bioprinting and also 3D inkjet printing in general has been the development of an advanced, sophisticated software to meet the challenge at the first step of printing – creating an appropriate design or blueprint. For instance, the blueprint of non-living objects can be created easily but when it comes to creating digital models of say, a liver or heart, its challenging and not straightforward like most material objects. Further, bioprinting definitely has multitude advantages - precise control, repeatability and individual design but is still plagued with several challenges with the most important one being inclusion of multiple cell types in a spatial structure since a living environment is dynamic and not static. This study has definitely contributed to the advancement of 3D bioprinting and lot of obstacles can be hopefully removed by following their principles. It is clear that the real success of bioprinting has several facets attached to it. The most crucial aspect which can empower bioprinting is the development of relevant and appropriate biomaterials, enhancement of the resolution of the printing and also vascularisation to be able to successfully apply this technology clinically. It does seem like a long way before fully functioning and viable organs for human transplant can be 'created' by bioprinting but nevertheless this field is progressing fast and plenty of developments are on the forefront now within just a last few years. It should be achievable to overcome most of the challenges attached with bioprinting since researchers and biomedical engineers are already on the path to a successful complex bioprinting.

Some issues with Bioprinting

An obvious critical point raised in the field of bioprinting is that it is almost impossible at this stage to test the efficacy and safety of any biological 'personalised' treatments being offered to patients using this technique. Also, costs associated with such treatments is also a big issue especially for where manufacturing is concerned and is not economically sound. Though it is very much possible to develop functional organs that can replace human organs, but even then, currently there is no fool proof way to assess whether the patient's body will accept the new tissue or the artificial organ generated and whether such transplants will be successful at all. Also, legal rules and regulations by appropriate authorities worldwide will also come in to play at this stage before any big promises are made to a wider audience. Another important aspect is to foresee any negative consequences like potential misuse of it, for example, trying to create super human with enormous capabilities or trying to create a clone, which could be detrimental to society and not to say completely illegal.

Bioprinting is a growing market and will focus on the development of tissues and organs and maybe in a few decades time new outcomes would be seen in 3D printed human organs and transplants. There is absolutely no doubt that 3D bioprinting will continue to be the most important and relevant medical development of our lifetime.

Source: Hedegaard, C.L 2018, 'Hydrodynamically Guided Hierarchical Self-Assembly of Peptide-Protein Bioinks', *Advanced Functional Materials*, 1703716, DOI: 10.1002/adfm.201703716

A 'New' Blood Test that Detects Cancers that are Undetectable till Date in Their Early Stages

In a major advancement in cancer screening, new study has developed a simple blood test to detect eight different cancers in their early stages, five of which do not have a screening program for early detection.

Cancer remains one of the leading causes of death worldwide. It is estimated that the number of global cancer deaths will have risen from 8 million to 13 million by 2030. Early diagnosis of cancer is extremely key to reduce cancer-related deaths because earlier the disease is diagnosed, the chances of a successful treatment become higher. The diagnosis of many cancers is a long and challenging process. When a person is having symptoms which suggest cancer, the doctor examines the personal and medical history and does a physical exam. After this initial assessment, many tests are generally recommended to be done. First, laboratory tests for blood, urine, body fluids etc are done which can help but usually do not diagnose cancer when done standalone. The doctor will generally suggest one or more medical imaging procedures which create pictures of areas inside the body that help the doctor see whether a tumour is present – an ultrasound or a CT scan to begin with.

Additionally, in most cases, doctors will need to do a biopsy to make a diagnosis of cancer - biopsy is a procedure in which the doctor removes a sample of tissue from the body to be examined in the laboratory to see if it is cancer. This tissue material can be removed from the body using a needle or minor surgical procedure or through endoscopy. This is an elaborate and complex diagnosis process, generally done after the patient starts to show off at least one obvious symptom which then compels him or her to visit the doctor. Many adult cancers grow very slowly, sometimes taking 20 to 30 years to progress to full-blown cancers. Thus, by the time they are diagnosed these cancers have often spread, making them incredibly difficult to treat. Since for many cancers, it is too late when the first symptom appears, this is a major concern for future of cancer diagnostics because earlier the information is available, more likely can the cancer treatment be successful. Unfortunately, many cancers are not caught until the later stages and this is attributed to lack of fast and effective diagnostic tools.

How does this new, innovative cancer screening blood test work?

In a recent study published in Science, researchers have developed a new blood test, which can offer a more simplified yet effective diagnostic technique for many cancers[1]. The test called as 'CancerSEEK', is a novel, non-invasive method to simultaneously detect eight cancer types from only one blood sample. This study carried out by a team at Johns Hopkins University School of Medicine, USA, has demonstrated high specificity and sensitivity for cancer detection among more than 1000 people with cancer and is being touted as a quick and simple way to detect cancer in its early stages and also pinpoint its location.

The study of CancerSEEK has been concluded on 1,005 individuals diagnosed with non-metastatic forms of one of the eight cancers (breast, lung, colorectal, ovarian, liver, stomach, pancreatic, and esophageal stages I to III), for five of which no routine early screening tests are available for people at average risk (those being ovarian, liver, stomach, pancreatic and esophageal). It is very simplistic how this blood tests works to identify the cancer. When cancerous tumours form inside the body after the onset of the disease, these tumour cells release small fragments of mutated DNA and abnormal proteins which circulate into the bloodstream and can act as highly specific markers for cancer. These minute amounts of mutated DNA and abnormal proteins circulate in the blood long before causing any symptoms and are very unique compared to the DNA and proteins found in normal cells. Thus, this blood test works by identifying the markers for 16 gene mutations and eight common cancer proteins (shortlisted after initially exploring several hundred genes and 40 protein markers) that are associated with eight different cancer types indicating the presence of cancer. The small yet robust mutation panel could detect at least one mutation in the different cancers. This identification of cancer markers is a unique classification method because it combines the probability of observing various DNA mutations together with the levels of several proteins in order to take a final diagnosis decision. This method is based on the same rationale for using combinations of drugs to treat cancers. It is important to note that this molecular test is aimed at screening for cancer and is very different from other molecular tests which analyse large numbers of cancer-driving genes to identify targets which can be used to develop therapeutics.

Potential of the test to be impactful for patients

The test yielded an overall result of more than 99 percent and the test was able to identify 70 percent of the cancers with overall sensitivity ranging from lowest 33 (for breast cancer) to an impressive 98 percent (for ovarian cancer). The sensitivity for the five cancers for which no screening tests are available (pancreas, ovary, liver, stomach and esophageal) ranged from 69 to 98 percent. Interestingly, the test was also able to pinpoint the location of tumours in 83 percent of the patients. These results are termed as very 'encouraging' and points towards the possibility of having CancerSEEK as a routine screening test for cancer since it has a potential to

substantially impact patients to improve outcomes. The overall specificity of the test was also high and this is extremely crucial for avoiding overdiagnosis and unnecessary invasive follow-up tests and procedures to confirm the presence of cancer. This specificity was mainly achieved by keeping the mutation panel small. This test was performed on 812 healthy participants and only seven were flagged positive by CancerSEEK, and these patients could be either false positives or even might have early-stage cancer with no symptoms.

Comparing CancerSEEK with other early detection tests

Blood sample have been used for cancer detection, in what is called 'liquid biopsies' (compared to normal biopsy in which a sample tissue is removed from the body and is more invasive). These procedures generally survey a large number of genes in an attempt to identify therapeutic targets for drugs. In comparison, CancerSEEK follows an entirely different approach of focusing on early diagnosis of cancer by looking at mutations in just 16 cancer-associated genes and the levels of eight protein as cancer biomarkers. The results from these two parameters could be combined with an algorithm to "score" each blood test which can further ensure the accuracy and reliability of the results. Unfortunately, blood-based "liquid biopsy" tests have been recently tagged as controversial in accurately detect cancer mutations, with their failure in indicating the location of the tumours. Also, they are very expensive - upto several-thousand-dollar – and their ability to become routine tools for diagnosing and guiding treatment for cancer patients is becoming questionable. Remarkably, in this study, in 63% of patients, CancerSEEK specified the organs giving information on how to pinpoint the location of the tumour and in 83% patients, this test pointed two autonomical locations.

Many effective early-cancer detection tests do exist for some cancer types, example mammography for breast cancer and cervical pap smears for cervical cancer. The only widely-used blood-based test is for prostate cancer which looks at just a single protein biomarker, prostate specific antigen (PSA). Though this test has been around for more than three decades, this blood-based test is still not being tagged as useful and necessary.

However, some proven screening tests that lead to earlier diagnosis, such as colonoscopy screening for bowel cancer, have associated risks and only screen for one cancer at a time. Also, other blood-based tests for cancer diagnosis like GRAIL[2], which has a very strong backing for clinical trials, only tests for tumour DNA, not the additional protein biomarkers which CancerSEEK now includes. Thus, it should be clear in the future which of these two technologies have better vital elements like ability to detect different cancer types and avoiding false-positives. Also, most screenings for specific cancer types are only recommended for people who might be or are expected to at risk owing to their family history of cancer or just older age). Thus, CancerSEEK could be a mainstream for even healthy patients with no signs.

Future

It is non-debatable that early diagnosis is most critical to avoid the potentially devastating impact of many cancer treatments and cancer deaths. Despite the gains made in cancer treatment, advanced cancer care still bears a lot of physical, mental and financial bearings. The cancers which are still localised to their tissue of origin and have not spread beyond can often be cured by surgery alone, thus sparing a patient from the considerable side effects of chemotherapy and radiotherapy treatments.

Researchers hope that CancerSEEK can in the future offer a simple, non-invasive and fast strategy for diagnosing cancer in its early stages. The authors point out that they have adopted a realistic approach during this study and understand that no single test will be able to detect all cancers and although the current test does not pick up every cancer, it does successfully identify many

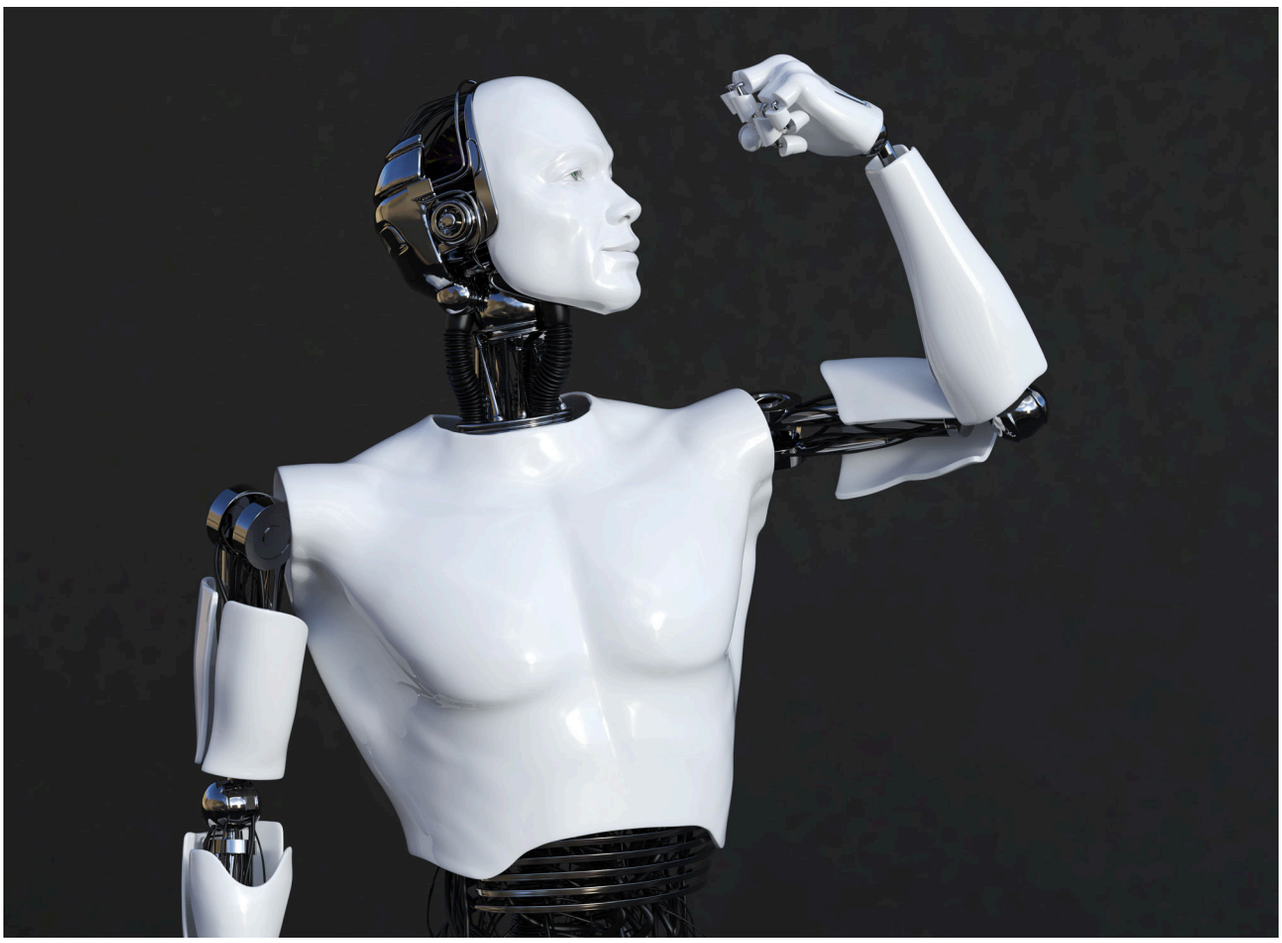
cancers that would otherwise likely go undetected. Also, the proposed cost of CancerSEEK is about $500 and this is far more economical that most currently available screens for just a single cancer types thus can be highly prospecting. The ultimate vision provided by the authors is to have this test being incorporated in routine check-up (preventive or otherwise) in primary health care setting itself, something similar to let's say a cholesterol check. However, it might take some years for this test to be available in clinic.

To establish this test further, it is necessary to demonstrate how this test can be effective in saving lives one day and so large trials are now underway in the USA for which the results will be available in the next three to five years. Thus, as exciting as this study maybe, oncologists worldwide are waiting for the ongoing large-scale trials to be completed.

However, there is no doubt that this unique test has paved the path to shift the focus in cancer research from late-stage cancer to early disease which will be critical in reducing cancer deaths in the long term.

Source:
1. Cohen et al., 2018, 'Detection and localization of surgically resectable cancers with a multi-analyte blood test', *Science*, eaar3247, DOI: 10.1126/science.aar3247
2. Aravanis et al., 2017, 'Next-Generation Sequencing of Circulating Tumor DNA for Early Cancer Detection', *Cell,* vol.168, no. 4, pp.571–574. DOI: 10.1016/j.cell.2017.01.030

Artificial Muscle



In a major advancement in robotics, robot with 'soft' human-like muscles have been successfully designed for the first time. Such soft robots can be a boon to design human friendly robots in the future.

Robots are programmable machines that are routinely used in industrial applications, example as part of automation, especially manufacturing because they are designed to be good at repetitive tasks which require a lot of strength and power, example in car manufacturing. Robots interact with the physical world via sensors and actuators in them and they are reprogrammable, making them more useful and flexible than routine single-function machines. It is obvious from the way these robots are designed to do the job, their motions are extremely rigid, sometimes jerky, machine-like and they are heavy, imposing and they are not really useful when a particular task requires variable amounts of force at different time points. Robots are also sometimes dangerous and might need secure enclosures as they are not sensitive to their surroundings. The field of robotics is exploring a variety of disciplines to design, build, program and efficiently use robotic machines in various areas of industry and medical technology with different requirements.

In a recent dual set of studies led by Christoph Keplinger, researchers have fit the robots with a new class of muscles, which are very similar to our human muscles and they possess as well as project strength and sensitivity just like we do. The central idea is to provide more "natural" movements to the machine i.e. robots. 99.9 percent of all robots today are rigid machines made out of steel or metal, whereas a biological body is though soft but has incredible capabilities.

These robots with 'soft' or 'more real' muscles can be suitably designed to perform routine and delicate tasks (which human muscles perform on a daily basis), for example just picking up a soft fruit or placing an egg softy inside a basket. Therefore, compared to the traditional robots, these robots fitted with 'artificial muscles' will be like a 'softer' versions of themselves and obviously safer and they could then be customized to perform almost any task in the proximity of people, suggesting several possible applications associated with and around human life. Such soft robots could be referred to as 'collaborative' robots, as they will be uniquely designed to carry out a particular task in a very similar way as a human.

For quite sometime researchers have been trying to create soft muscle robots. Such a robot will require a soft muscle technology to impersonate the human muscles and two such technologies have been tried by researchers - pneumatic actuators and dielectric elastomer actuators. The 'actuator' is defined as the actual device which moves the robot, or the robot shows a particular movement. In pneumatic actuators, a soft pouch is pumped with gases or fluids to create a particular movement. This is simple design but still powerful though the pumps are impractical and they have bulky reservoirs. Based upon the pump set up, moving gases or liquids can also be a very slow process. The second technology – dielectric elastomer actuators use the concept of applying an electric field across an insulating flexible plastic to deform it and thus creating a movement. These two technologies on their own have not yet tasted success because when a bolt of electricity passes through the plastic, these devices fail miserably and thus are not resistant to mechanical damage.

More "human like" robots with similar muscles

In these studies, reported in *Science* and *Sciences Robotics*, researchers took the positive aspects of these two available soft muscle technologies and created a simple soft muscle-like actuator that uses electricity to alter the movement of liquids inside small pouches. These flexible polymer pouches contain an insulating liquid, example a regular oil (vegetable oil or canola oil) from the supermarket, in fact any similar liquid can be used. Once voltage was applied between the hydrogel electrodes placed between the two sides of the pouch, the sides were drawn to each other, oil spasm takes place, squeezing the liquid in it and causing it to flow around inside the pouch. This tension creates an artificial muscle contraction and once the electricity is cut off, the oil relaxes again, imitating an artificial muscle relaxation. The actuator changes shape in this manner, and the object which is connected to the actuator shows a movement. Therefore, this 'artificial muscle' contracts and releases (flex) instantly in milliseconds, basically in the same manner and with the same precision and force of real skeletal human muscles. These movements can even beat the speed of human muscle reactions because human muscles concurrently communicate with the brain causing a delay, though unnoticeable. Therefore, through this design, a fluid system was achieved which had direct electrical control exhibiting versatility and high performance.

In the first study[1] in *Science*, actuators were designed in the shape of a doughnut and they had the capability and dexterity to pick up and hold a raspberry through a robotic gripper (and not exploding the fruit!). The possible damage which was done by a bolt of electricity when passed through the insulating liquid (a major issue with the previously designed actuators) was also take care of in the current design and any electrical damage was self-healed or repaired instantly by just new flow of liquid into the 'damaged' part through a simple process of redistribution. This was attributed to the use of liquid material, which is more resilient, in place of a solid insulating layer used in many previous designs and which was damaged instantly. Interestingly, in this process, the artificial muscle survived more than a million contraction cycles. This particular actuator, being dough-nut shaped was easily able to pick a raspberry. Similarly, by tailoring the shape of these elastic pouches, researchers created a wide range of actuators with unique movements, example even picking up a fragile egg with precision and exact required force. These flexible muscles have been termed as "Hydraulically-amplified Self-healing Electrostatic" actuators, or HASEL actuators. In a second study[2] published in *Science Robotics*, the same team further created two other soft muscle designs which contract linearly, very similar to a human bicep, thus having the capability to repeatedly lift objects heavier than their own weight.

A general opinion might be that since robots are machines so they surely must be having an edge over humans, but, when it comes to the astonishing abilities afforded us by our muscles, one could simply say that robots really pale in comparison. The human muscle is extremely powerful and our brain has an extraordinary amount of control over our muscles. This is the reason human muscles are capable of performing intricate tasks with precision e.g. writing. Our muscles repeatedly contract and relax when doing a heavy task and it is said that we actually use only about 65 percent capability of our muscles and this limit is mainly set by our thinking. Thus, if we can imagine a robot who has human-like soft muscles, the strength and capabilities would be enormous. The current study is seen as a first step to develop an actuator which could one possible day achieve the enormous capabilities of real biological muscles.

Cost effective 'soft' Robotics

The authors say that material like the potato-chips polymer pouches, oil and even electrodes are not only inexpensive but also readily available making the cost of such to be only 0.9 USD (or 10 cents). This is encouraging not only for current industrial manufacturing units but also for researchers to further their expertise. These materials being low-cost are scalable and compatible with the current industry practises as well and such devices could be used for a number of applications like prosthetic devices, or as a human companion. This is a particularly interesting aspect, since the term robotics is always equated with high costs. However, a drawback associated with such artificial muscles is the high amount of electricity required for its operation and there are also chances of burning if the robot reserves too much of its power. Also, such soft robots are far more delicate than their traditional robot counterparts and thus several aspects during their design needs to be taken care of by their designers, for example possibilities of puncturing, losing power and spilling the oil. These soft robots definitely need some kind of self-healing aspect, like many some soft robots already do.

Efficient and robust soft robots can be very useful in human lives as they can complement the humans and work with them and they can be more like "collaborative" robots rather than robots which replace humans. Also, traditional prosthetic arms could be more soft, pleasant and sensitive. These studies are a remarkable breakthrough in the field of soft robotics and if the high demand of power could be tackled, it has the potential to revolutionise the future of robots in terms of their design and how they move.

Source:
1. Acome et al., 2018, 'Hydraulically amplified self-healing electrostatic actuators with muscle-like performance', *Science*, vol. 359, no 6371, pp. 61-65, DOI: 10.1126/science.aao6139
2. Kellaris et al., 2018, 'Peano-HASEL actuators: Muscle-mimetic, electrohydraulic transducers that linearly contract on activation', *Science Robotics*, vol. 3, no. 14, eaar3276, DOI: 10.1126/scirobotics.aar3276

New Understanding of Schizophrenia

A recent breakthrough study unearths a new mechanism of schizophrenia

Schizophrenia is a chronic brain disorder that affects approximately 1.1% of the adult population or roughly 51 million people worldwide. When schizophrenia is in its active form, symptoms can include delusions, hallucinations, disorganized speech or behaviour, trouble with thinking, loss of concentration and lack of motivation. Schizophrenia is now widely known but is very poorly understood and its exact cause is still not completely clear. Scientists worldwide believe that a combination of genetics, brain chemistry and environmental factors contributes together towards development and advancement of schizophrenia. These findings have been established after using advanced imaging to look at the brain's structure and function. Also, schizophrenia cannot be prevented and no cure is available for it, though research is currently happening to develop new and safe treatments.

Early treatment of schizophrenia may help get the symptoms under control before any serious complications occur and can help to improve the long-term outcome for a patient. If a treatment plan is followed with care, it can help prevent relapses and also extreme worsening of the symptoms. New and effective therapies for an early diagnosis and treatment can hope to be developed once the risk factors for schizophrenia is clear. It has been proposed for quite some time that problems with certain naturally occurring chemicals in the brain – including

neurotransmitters called dopamine and glutamate – may contribute to schizophrenia and also other mental illnesses. These 'differences' are seen in neuroimaging studies on brain and the central nervous system of people who have schizophrenia. The exact significance of these differences or changes is still not very clear, but it definitely indicates that schizophrenia is a brain disorder. Schizophrenia requires a lifelong treatment and even in those patients where symptoms appear to have subsided. Generally, a combined treatment of medications and psychosocial therapy can help manage the condition and only in severe cases hospitalization may be needed. A team effort by health professionals is needed in the clinics with expertise in schizophrenia treatment. Most antipsychotic medications for schizophrenia treatment are thought to control symptoms by affecting the brain neurotransmitter dopamine. Unfortunately, many such medications tend to cause serious side effects (which can include drowsiness, muscle spasms, dry mouth and blurred vision), making the patients reluctant to take them and in some cases injections may be the chosen route instead of taking a pill. Clearly, to develop therapeutic interventions and drugs to target and treat schizophrenia, it's important to first understand the disorder by identifying all different possible mechanisms of actions.

A novel mechanism to understand and target schizophrenia

A recent study by neuroscientists from Case Western Reserve University School of Medicine, USA, led by Dr. Lin Mei, have uncovered a novel mechanism underlying the cause of schizophrenia. They have used genetic, electrophysiological, biochemical, and molecular techniques to uncover the function of a protein called neuregulin 3 (NRG3). This protein, belonging to the neuregulin protein family, has already been shown to be encoded by a 'risk' gene in various other mental illnesses including bipolar disorders and depression. And if we talk about schizophrenia, many variations in this particular gene (which encodes for NRG3) are considered as "major risk" factors. Several studies have been done on NRG3, but its exact and detailed physiological function is still very poorly understood. In this new study published in *Proceedings of National Academy of Sciences*, researchers while trying to uncover the potential function of NRG3, discovered that it is central to schizophrenia and could become a possible therapeutic target to treat it.

Researchers found that NRG3 protein mainly supresses a protein complex - which is very essential for proper neuron communication and the overall efficient working of the brain. The gene which encodes for NRG3 (so that it can effectively perform the function which it has to) was muted in mice in a certain number of neurons of the brain. Specifically, when the mutations were induced in the 'pyramidal' neurons - which play an important in activating the brain - mice displayed symptoms and behaviour in line with schizophrenia. The mice had healthy reflexes and also hearing capabilities, but showed unusual level of activity. They showed trouble in remembering (e.g. when navigating mazes) and also acted shy around stranger mice. Thus, it was clear that NRG3 plays a crucial role in schizophrenia and also the type of neurons involved were also defined. Further, researchers also uncovered how exactly this protein NRG3 works at the cellular level. It was seen that it basically inhibits an assembly of a complex of proteins at synapses – the place or junction where nerve cell or neurons communicate. The neurons need a complex (called SNARE, short for Soluble N-ethylmaleimide-sensitive factor activating protein receptor proteins), to transmit neurotransmitters (specifically glutamate) between each other at the synapses. People suffering from severe mental illnesses including schizophrenia, tend to have higher levels of NRG3 protein and these higher levels were responsible for supressing the release of glutamate – the naturally occurring neurotransmitter in the brain. This was seen in laboratory experiments that NRG3 could not form the 'SNARE complex' and thus glutamate levels were suppressed as a result of this.

Glutamate is abundant in the human body but is most prominently found in the brain. It is a highly 'stimulatory' or 'excitatory' neurotransmitter in our brain and is most critical for activating the neurons in the brain and thus essential for our learning, understanding and memory. This study concludes that NRG3 is very important for proper glutamate transmission in the brain

and glutamate imbalances cause schizophrenic symptoms. Also, the function described here is detailed for the first time and very unique from previous roles described of this particular protein NRG3 as well as other proteins belonging to the same family.

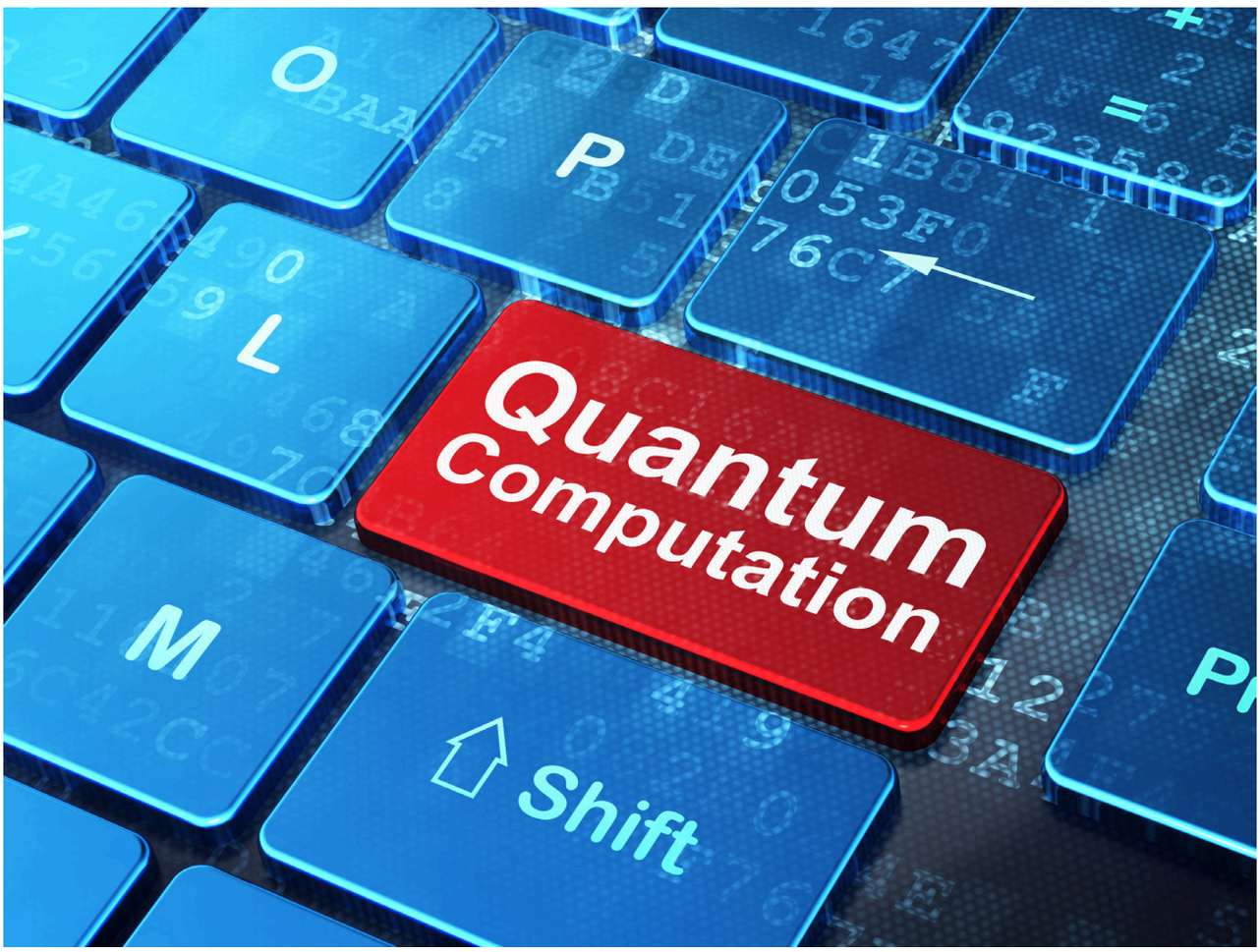
Therapeutics in the future

Schizophrenia is a very devastating mental illness which drastically affects various areas of life. It disrupts the daily life by affecting day to day functioning, self-care, relationships with family and friends and all kinds of social life. The patients are generally not seen to have a particular 'psychotic episode' but rather overall life outlook and balances get affected. Coping with a mental disorder as serious as schizophrenia is extremely challenging, both for the person with the condition and for friends and family. Schizophrenia is considered as among the top 10 most disabling conditions. Since schizophrenia is very complex, clinical effect of medications are also varied in different patients and generally do not succeed beyond a few trials. New therapeutic treatments are urgently needed for this condition and this study has shown a new direction towards developing one.

The NRG3 protein can definitely serve as a new therapeutic target to help treat schizophrenia and possibly other mental illnesses like bipolar and depression. Drugs could be designed which can target NRG3 thereby help to restore glutamate levels in specific types of neurons and thus restore brain's function during schizophrenia. This methodology can be a totally new approach towards treatment. This study has shed light on a novel cellular mechanism of schizophrenia and has generated immense hope in the field in mental illnesses. Though the path to discovering and launching effective drugs for treatment seems to appear very long at the moment, research is in the right direction at least.

Source: Wang et al. 2018, 'Controlling of glutamate release by neuregulin3 via inhibiting the assembly of the SNARE complex', *Proceedings of National Academy of Sciences*, published ahead of print, DOI: 10.1073/pnas.1716322115

A Step Closer to Quantum Computer



Series of breakthroughs in quantum computing

An ordinary computer, which is now also referred to as the classical or traditional computer works on the basic concept of 0s and 1s (zeroes and ones). This basically means that when we ask the computer to do a task for us, example a mathematical calculation or booking of an appointment or anything related to day to day life, this task at the given moment is converted (or translated) into a string of 0s and 1s (which is then called the input), this input is then processed by an algorithm (defined as a set of rules to be followed to complete a task on a computer). After this processing, a new string of 0s and 1s is returned (this is called the output), and this encodes for the expected result and is translated back into simpler user-friendly information as an "answer" to what the user wanted the computer to do. Thus, it is quite fascinating that no matter how smart or clever the algorithm might appear and whatever might be the level of difficulty of the task, a computer algorithm does only this one thing – manipulating string of bits – where each bit is either 0 or a 1. This manipulation happens on the computer (at the software end) and on the machine level, this is represented by electrical circuits (on the computer motherboard). In hardware terminology when current passes through these electrical circuits, it is closed and is open when there is no current.

Classical Vs Quantum computer

Therefore, in classical computers, a bit is a single piece of information which can exist in two possible states – 0 or 1. However, if we talk about quantum computers, they usually use quantum bits (also called 'qubits'). These are quantum systems with two states, however, unlike the usual bit (stored as 0 or 1), the qubits can store much more information and can actually exist in any supposition of these values. To explain in a better way, a qubit can be thought of like being an imaginary sphere, where qubit can be any point on the sphere. It can be said that quantum computing takes advantage of the ability of subatomic particles to exist in more than one state at any given time and still be mutually exclusive. On the other hand, a classical bit can only be in two states – example at the end of two poles of the sphere. In ordinary life we are not able to see this 'superposition' because once a system is viewed in its entirety, these superpositions disappear and this is the reason that the understanding of such superpositions is very unclear.

What this means for the computers is that quantum computers using qubits can store a huge amount of information using lesser energy than a classical computer and thus the operations or calculations can be relatively done much faster on a quantum computer. So, a classical computer can take a 0 or 1, two bits in this computer can be in four possible states (00, 01, 10 or 11), but only one state is represented at any given time. A quantum computer, on the other hand works with particles that can be in superposition, allowing two qubits to represent the exact same four states at the same time because of the property of superposition, freeing up the computers from 'binary constraint'. This can be equivalent to four computers running simultaneously and if we add these qubits, the power of the quantum computer grows exponentially. The quantum computers also take advantage of another property of quantum physics called 'quantum entanglement', defined by Albert Einstein, entanglement is a property which allows quantum particles to connect and communicate regardless of their location in the universe so that changing the state of one may instantaneously affect the other. The dual capabilities of 'superposition' and 'entanglement' are quite powerful in principle. Therefore, what a quantum computer can achieve is unimaginable when compared to classical computers. This all sounds very exciting and straightforward, however, there is problem in this scenario. A quantum computer, if takes qubits (superposed bits) as its input, its output will also be similarly in a quantum state i.e. an output having superposed bits which can also keep changing depending on what state it is in. This kind of output doesn't really allow us to get all the information and therefore the biggest challenge in the art of quantum computing is to find ways of gaining as much information from this quantum output.

Quantum computer will be here!

Quantum computers can be defined as powerful machines, based on the principals of quantum mechanics that take a completely new approach to processing information. They seek to explore complex laws of nature that have always existed but have usually remained hidden. If such natural phenomena can be explored, quantum computing can run new types of algorithms to process information and this could lead to innovative breakthroughs in materials science, drug discovery, robotics and artificial intelligence. The idea of a quantum computer was proposed by American theoretical physicist Richard Feynman way back in 1982. And today, in the 21st century, technology companies (such as IBM, Microsoft, Google, Intel) and academic institutions (like MIT, and Princeton University) are working on quantum computer prototypes to create a mainstream quantum computer. International Business Machines Corp. (IBM) has said recently that its scientists have built a powerful quantum computing platform and it can be made available for access it but stress that it's really not enough for performing most of the tasks. They say that a 50-qubit prototype which they are currently developing, can solve a lot of problems which classical computers do today and in the future 50-100 qubit computers would largely fill the gap i.e. a quantum computer with just a few hundred qubits would be able to perform more calculations simultaneously than there are atoms in the known universe. Realistically speaking, the path to where a quantum computer can actually outperform a classical computer on difficult tasks is laden with difficulties and challenges. Also, very recently Intel has declared that the company's

new 49-qubit quantum computer represented a step towards this "quantum supremacy", in a major advancement for the company who had demonstrated a 17-bit qubit system only just 2 months ago. Their priority is to keep expanding the project, based upon the understanding that expanding the number of qubits is the key to creating quantum computers that can deliver real-world results.

Material is key for building quantum computer

The material, silicon has been an integral part of computing for decades because its key set of capabilities make it well suited for general (or classical) computing. However, as far as quantum computing is concerned, silicon-based solutions haven't really been adopted mainly because of two reasons, firstly it's difficult to control qubits manufactured on silicon, and secondly, it's still unclear if silicon qubits could scale as well as other solutions. In a major advancement, Intel has very recently developed1 a new type of qubit known as a 'spin qubit' which is produced on conventional silicon. Spin qubits closely resemble the semiconductor electronics and they deliver their quantum power by leveraging the spin of a single electron on a silicon device and controlling the movement with tiny, microwave pulses. The two major advantages which led to Intel move in this direction are, firstly Intel as a company is already heavily invested in the silicon industry and thus has the right expertise in silicon. Secondly, silicon qubits are more beneficial because they are smaller than conventional qubits, and they are expected to hold coherence for a longer period of time. This is obviously of a lot of importance when quantum computing systems needs to be scaled up (e.g. going from 100-qubit to 200-qubit). Intel is testing this prototype and the company expects to be producing chips having thousands of small qubit arrays and such a production when done in bulk can be very good for scaling up the quantum computers and can be a real gamechanger.

Also, in a recent research published in *Science*, a newly designed pattern for photonic crystals (i.e. a crystal design implemented on a photonic chip) has been developed by a team at University of Maryland, USA, which they claim will make quantum computers more accessible[2]. These photons are the smallest amount of light known and these crystals were entrenched with holes which causes the light to interact. Different hole patterns change the way the light bends and bounces through the crystal and here thousand of triangular holes were made. Such a use of single photons is important for the process of creating quantum computers because the computers will then have the ability to calculate large numbers and chemical reactions that the type of computers used now aren't able to do. The chip's design makes it possible for the transfer of photons between quantum computers to occur without any losses. This loss has also been viewed as a big challenge for quantum computers and thus this chip takes care of the issue and allows efficient route of quantum information from one system to another.

Future

Quantum computers promise to run calculations much beyond any conventional supercomputer. Thus, they have the potential to revolutionize the discovery of new materials by making it possible to simulate the behaviour of matter down to the atomic level. It also builds up hope for artificial intelligence and robotics by processing data faster and much more efficiently. It is being said for 'quantum computing' that delivering a commercially viable quantum computing system could be done by any of major organizations in the coming years since this research is still open ended and a fair game for all. Major announcements are expected in the coming five to seven years and ideally speaking with the series of advancements being made, engineering problems should be addressed and a 1 million or more qubits quantum computer should be a reality.

Source
1. Castelvecchi, D. 2018, 'Silicon gains ground in quantum-computing race' *Nature*, vol. 553, no 7687, pp.136-137, DOI: 10.1038/d41586-018-00213-3
2. Sabyasachi, B. et al., 2018, 'A topological quantum optics interface', *Science*, vol. 359, no. 6376, pp.666-668, DOI: 10.1126/science.aaq0327

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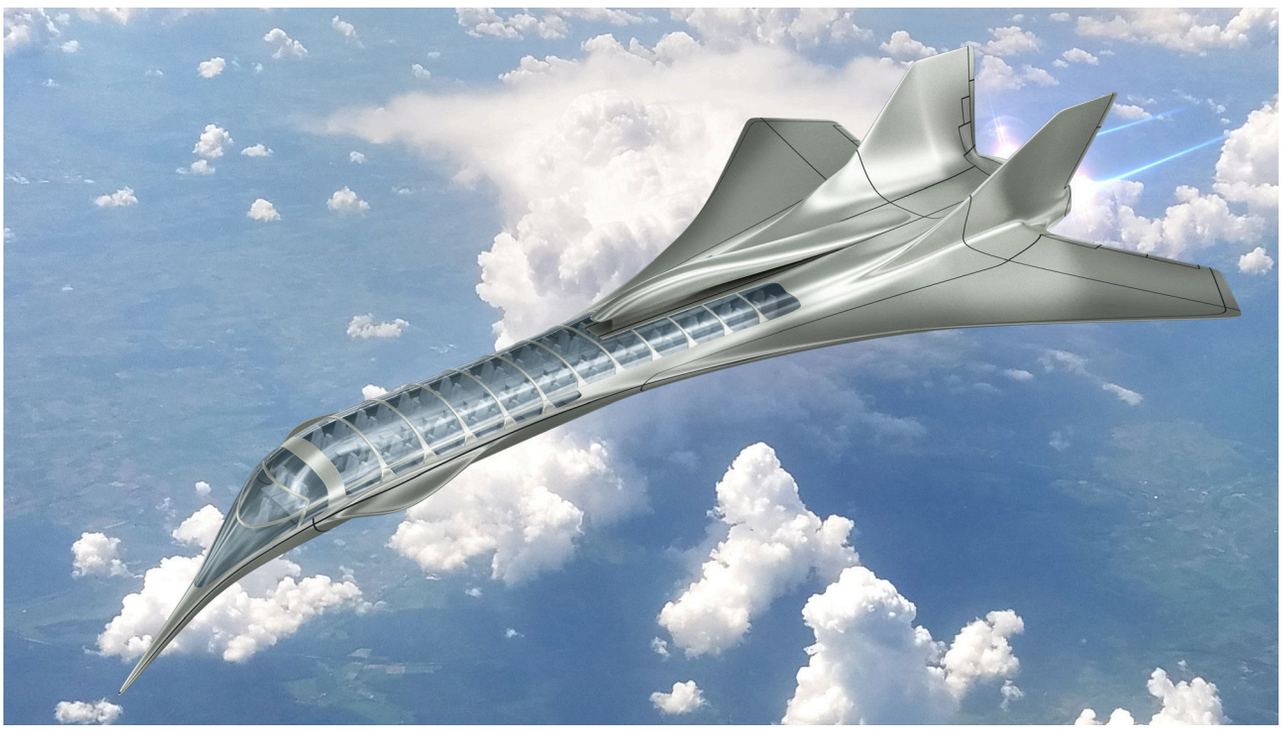

China has successfully tested a hypersonic jet plane which could cut down the travel time by almost one-seventh.

China has designed and tested an ultra-fast aircraft which can achieve hypersonic speeds in the range of Mach 5 to Mach 7, which is about than 3,800 to 5,370 miles per hour. Hypersonic speeds are 'super' supersonic (which are Mach 1 and above) speed. Researchers from the Chinese Academy of Sciences, Beijing have successfully tested their "I Plane" (resembling the capital 'I' at when viewed from the front and also having an 'I' shaped shadow when it flies) inside a wind tunnel at these speeds and they state that such a hypersonic plane would only need a "couple of hours" to travel from Beijing to New York when a commercial airline flight currently takes a minimum of 14 hours to cover this distance of 6,824 miles. When compared with the existing aircraft, Boeing 737, the I Plane's lift was roughly 25 percent, i.e. if a 737 aircraft had an ability to carry up to 20 tonnes, or 200 passengers, the I Plane of the same size could carry 5 tonnes or roughly 50 passengers. The idea of a hypersonic plane being used as a commercialized aircraft has been around for quite a while and the race to be the first to use it has already begun.

This research, published in *Science China Physics, Mechanics & Astronomy*, has put the topic of hypersonic airplanes back into the limelight. During the testing and aerodynamic evaluations and experimentations, researchers scaled-down the model of the plane inside a specially designed wind tunnel. It was seen that the wings of the I Plane work well together to reduce turbulence and drag while continuously boosting the plane's overall lift capacity. The lift in airplane terminology is referred to the mechanical aerodynamic force that directly opposes the total weight of an airplane and thus holds the airplane in the air. This lift is generated by every part of the airplane,

example in most commercial aircrafts this lift is solely generated by its wings. The lift capacity of an aircraft is very important to keep it steady in the air. And drag and turbulence (caused by heat, jet stream, flying over mountains etc) are basically the aerodynamic forces which oppose and aircraft's motion in the air. So, the central idea is to maintain a high and steady lift and reduce drag and the effects of turbulence. The authors even pushed the model plan to seven times the speed of sound (343 metres per second, or 767 miles per hour) and to their delight it delivered consistent performance, with high lift and low drag. The design of the aircraft included lower wings that reach out from the middle of the fuselage like a pair of embracing arms. And a third flat, bat-shaped wing meanwhile extends over the back of the aircraft. Thus, owing to this design, the double layer of wings works together to reduce turbulence and drag when at extremely high speeds while increasing the aircraft's overall lift capacity.

Major countries including China and the United States are also in the process of developing hypersonic weapons and a hypersonic vehicle which could be sued by the military as a defence system. This is very confidential and not to say highly debatable because of the unforeseen limits such hypersonic devices could achieve. China is also aiming at a future hypersonic plane which will include a wind tunnel that can produce speeds of up to Mach 36, making it the fastest ever. This can be a game changer and all these developments are really shaking things up in the hypersonic research community.

Technological Challenges

This study, through its aerodynamic design, has successfully addressed the problems that were faced by previous hypersonic plane models, however the real success would be achieved by moving it ahead from the conceptual stage to a real one. Previous known hypersonic vehicles that have been developed worldwide have gotten stuck at the experimental stage because of the various technological challenges that have existed and in fact still exist. For example, any aircraft travelling at hypersonic speed will generate enormous heat (possibly exceeding 1,000 degrees Celsius) and this heat will need to be either insulated or dispersed efficiently or it could prove fatal for the machine and its carriers. This problem has been suitably addressed many times example by using heat-resistant materials and also an inbuilt liquid-cooling system to thrust the heat out – but all this is technically proven only at the experimental stage. These tests need to move from the wind tunnel to an open field (i.e. experimental setup to a real environment). Nevertheless, this is an exhilarating study and it could pave the path for the future of hypersonic technology.

Source:
Cui et al., 2018, 'Hypersonic I-shaped aerodynamic configurations', *Science China Physics, Mechanics & Astronomy*, vol. 61, no. 2, 024722, DOI: 10.1007/s11433-017-9117-8

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