Genesis

APR 2021

What We Infer From Pandemics In The Past

Epigenetics

Movies

Research in Pilani

And much more...

Mobile RT-PCR:

In Talks with

Dr Chandrasekhar Nair

This Issue is Dedicated to the memory of

Dr Sandhya Mitra

Breast Cancer And NIRAMAI

Interview with Dr Sridhar Ramanathan

IN THIS ISSUE

"If I have seen further than others, it is by standing upon the shoulders of giants."
- Issac Newton

The charm of science lies in the fact that the progress we see today is because of the progressive effort of multiple minds to work for a common goal. And every aspect of the cycle of learning, developing and spreading science is essential for its growth because it is something much bigger than oneself. Keeping this spirit in mind, we dedicate this issue to the memory of Dr Sandhya Mitra, a beloved professor who devoted her life to science education. This magazine strives to inspire and stimulate young and old minds alike while hoping that every reader takes home something new.

We have interviews with dynamic personalities who have been the front-runners for health care based solutions during the pandemic; Dr Chandrashekar Nair and Dr Sridhar Ramanathan. We bring a brief on some of the research ongoings in the Biological Sciences Department of BITS Pilani and the latest updates on some of the hottest topics in biosciences. The simple yet insightful nature of the articles ensures that you will be able to enjoy it irrespective of your background.

Enjoy the magazine!

Aryahi
Editor-in-Chief

In Remembrance of Dr Sandhya Mitra
(Cherishing fond memories of Mama Di.)
1

Research in Pilani
(In talks with Dr Vishal Saxena on Plasmodium Vivax.)
6

Question and Answers
(Why, What, When, How of everyday life.)
7

Alum Talk: Interview with Dr Sridhar Ramanathan, President and CTO of HealthCubed
(A Journey from BITS to AI-based Health-care.)
11

Epigenetics
(An insight into how your environment gets the better of genetics.)
13

Life on Venus
(Exploration to the prospect of life from outer space.)
18

Alum Talk: Interview with Dr Chandrasekhar Nair, Founding Director of BigTec Pvt. limited
(On the development of chip-based RT-PCR kits.)

The science behind Movies
(*Between the lines of fiction and Science.)*
22

Research in Pilani
(In talks with Dr Rajdeep Chowdhury on drug resistance in cancer.)
28

Species Alert
(Say hi to new co-habitants discovered in 2020.)
31

Pandemic Infographics
(Plagues through the years,)
33

Biomimicry
(*The best of what we learn from nature.)*
35

Vaccine Infographics
(Brief status of vaccines around the world.)
39

Research in Piani
(In talks with Dr Jitendra Panwar on using silver and bacteria.)
41

Research in Focus
(An article you might want to check out.)
44

BioTube
(Watch these when you open Youtube next)
45

Metal Bacteria
(The implications on the environment)
48

Crossing Lines
(What is happening in Biology and …)
51

BioHackers
(A review)
48

Biomolecules
(Chemicals that matter)
53

Acknowledgement

This magazine would not be possible if not for the works of the many scientists and lovers of science and their works. We thank them and we hope that they continue to support the free and open nature of science.

In Remembrance of Mama Di:

Cherishing fond memories of Dr. Sandhya Mitra at BITS Pilani

A multi-dimensional personality, Dr Sandhya Mitra has inspired many students over the decades from diverse fields of science and engineering to take a passionate interest in life sciences. Those who have benefitted from her teaching and wisdom can be found across the globe. She had earned her PhD from Columbia University, and had trained under several eminent scientists there, and at Rockefeller Institute of Medical research. Mentored by the very best, Dr Mitra was a visionary who was pivotal in setting up many of the labs that we see today in the Biological Sciences Department of BITS Pilani. She was the first in India to introduce (in 1983) an undergraduate course in Genetic Engineering. She was a caring mentor, a curious scientist, a comforting friend, a dynamic role model, a graceful woman, a powerful writer, a well-learned scholar and so much more. Her impact has been so diverse that it wouldn't be just to associate her with only one of her accomplishments. Having lived a long and fulfilling life, she continues to inspire even after her demise.

The enthusiasm shown by her students towards contributing to this article itself stands as a testament to how good a teacher and mentor she was. She joined BITS in 1969 and carved a niche out for herself in the history of BITS. She was an iconic teacher and was described to be so lively that she was often more energetic than her students. Her classes would often involve discussions of the latest advances in genetics and cell biology. When Dr Barbara McClintock won the Nobel Prize in 1983, Dr Mitra was found distributing posters in S-block and M-block, enthusiastically telling everyone about it for weeks. Some of her most noteworthy qualities were her determination and her clear vision for exactly how she wanted things to be. In 1984, while renovating labs, Dr Mitra worked her way through the bureaucracy and other obstacles to set up some of the best labs in the country at that time. Where others saw dusty old spaces, she saw an opportunity for growth. She was eager to explore and tread on territories that nobody else had. Hours were spent on devising protocols that generations of BITsians would follow for years to come and we are forever indebted to her for the foundations that she laid.

Dr. Mitra in BITS Pilani 1982

Dr. Mitra in BITS Pilani 1983

Dr. Mitra in BITS Pilani 1984

Dr Mitra being felicitated by her students during a reunion.

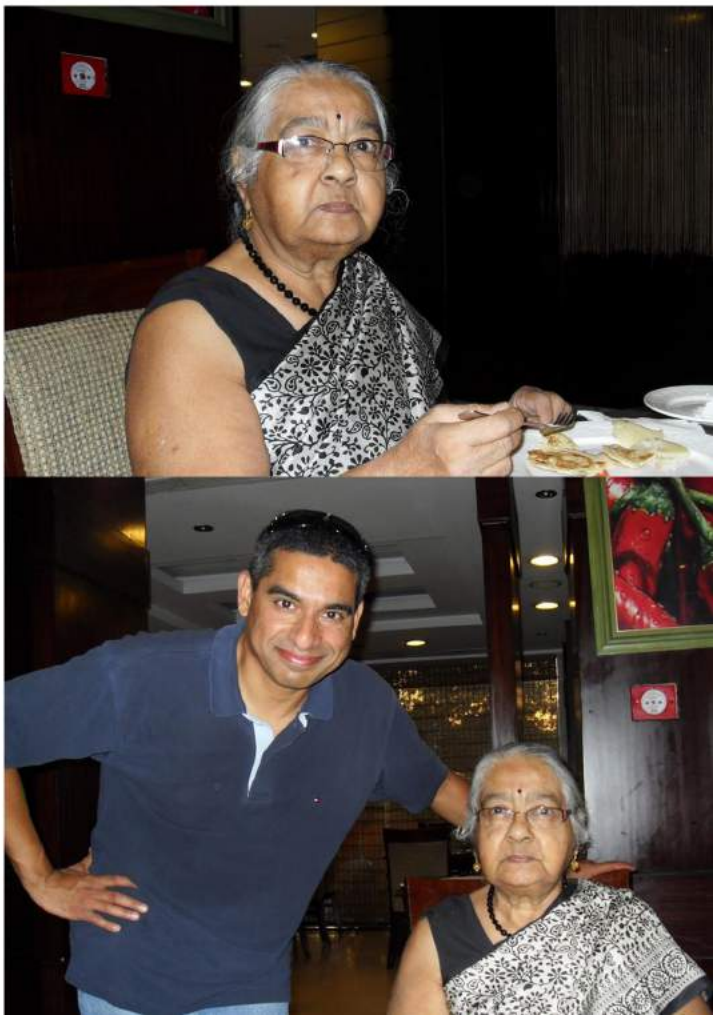
If one would stroll across the library, they would find Dr Mitra devouring the latest issues of journals like Cell, Nature, JMB, PNAS, Biosciences and many others, cover to cover, with the fervour of a teenager with comic books. At that time when online repositories were nonexistent, she would be found encouraging others to make the best use of the copies of the journals. She prioritized science and her passion for it over everything else. There was no journal on genetics in the library that she had not laid eyes on yet she yearned to learn more from every source that she could. She was particularly impressed with the antibody work of Dr Susumu Tonegawa, another Nobel Laureate. In 1987,when Professor Tonegawa was awarded the Nobel Prize in Medicine, the genetic mechanism of antibody diversification was a fairly new concept and she was the only one on campus with a clear grasp of it.

Dr Mitra was a talented artist and even drew the diagrams in her textbooks including those of rabbits, fruit flies and other model organisms. While she was more knowledgeable than most people her age, Dr Mitra was also as vivacious as her young students at BITS Pilani. She would use BITsian lingo and be often found hanging around with students and being one of them rather than just a professor. There was one instance where she surprised them by joining them on the roof of the bus on a trip. She would often pride herself on her health and even refused to accept seats from students on her bus as she didn't want to be the old woman who needed to sit. One could often spot her in social events on campus dancing away with grace and poise. She had the curiosity of a 5-year-old, energy of a 15-year-old and wisdom of a 50-year-old.

A person like her who is charming and oozing with enthusiasm might often tend to intimidate or overwhelm people around her. But Dr Mitra was so elegant in carrying herself that she not only was a source of inspiration but also encouraged everyone to be the very best version of themselves. She believed and made others believe that if she could do it, so could they.

During her time on campus, the concepts of cell phones or emails were nonexistent. She reached out to students and 'adopted' many a homesick student, took them under her wing and even insisted that they call her "Mama Di". She filled the shoes of a cool aunt with whom her students could be comfortable with. She established a strong relationship with her students, spending many nights listening to them talk about their diverse cultural backgrounds and requesting them to bring back delicacies. She would playfully chide them when she found them loitering around campus. She would see them off at the Pilani bus stop when they were leaving campus and even hand them a few rupees to grab a bite on the way. She was extremely fascinated by different cultures and was instrumental in introducing, and organizing popular extracurricular cultural programs such as 'Mitali', 'Manjusha', and 'Urvashi', and also directed some editions of these. She introduced several items into the annual cultural festival of BITS Pilani - Oasis, and started the series of lectures by students in the forum known as 'Ideation'.

Pictrue of Dr Mitra from the reunion in 2011, Dr Mitra with her student Dr Chandrashekar



Dr Mitra with students of BITS Pilani during her last visit

Mentoring and science seemed to come to Dr Mitra naturally. She had an unconventional manner of nurturing young scientists. When one of her students expressed difficulty with writing manuscripts, she simply suggested writing it like one would write a letter. She wanted to make science seem simple and logical that anybody could comprehend it and rid it of its sophisticated appearance.

It is often observed that a mentor might turn down proposals because of how unfeasible they might seem. Yet, Dr Mitra had some of the most distinctive thesis projects under her, which were proposed by her students. One such thesis project involved performing a transcriptomic and proteomic analysis of Dictyostelium, which was extremely difficult to culture in the lab. The isolation of RNA with the equipment at that time was extremely difficult and there was no formal protocol established for the organism. The extraction was not possible, however, she still awarded an A for the thesis for the enthusiasm. She let her students explore on their own and learn from their experiences thus making sure that they embody the spirit of science rather than just performing a successful experiment. Unlike a traditional biologist, she believed that biology was an amalgamation of physics, chemistry, and mathematics rather than it being an isolated field of its own.

The human genome project, the first noteworthy use of computers for gene sequencing was proposed in 1990 and completed in 2003. Back in 1984, Dr Mitra had a thesis under her supervision with the title 'computer-aided application in DNA sequencing'. However, it is not only the content of the project that is interesting. Dr Gora Datta, at that time, was a dual major in Chemistry and Chemical, however, had a strong inclination towards computer sciences. He had known Dr Mitra through cultural events on campus. He had developed an interest in genomics and approached her with the proposal. Initially, she refused it as she did not know much about computers. Neither were they common or user friendly. A small chat later, she replied, "I will accept the proposal only under one condition; you shall teach me how to use a computer." The next few months was an enriching experience for both of them while M'am learnt how to handle sequences with a computer; an IBM1130 which worked by punching cards. Little were they aware that the concept behind that thesis would blow up to become the basis of genomic analysis today. She took up every opportunity to learn something new, irrespective of where it came from.

One could often spot her driving around in her ambassador car around campus. When she wanted to talk to someone, she would honk outside their hostel, take them for a ride, talk about how exactly she wanted her textbook to be (which she published later).

Years later, even after her retirement, she would visit Pilani often, which she referred to as her home. Her relationship with everyone she mentored is with that level of comfort of a mother with her child. She would make time to meet everyone close to her in all her visits. The smallest things brought happiness to her, like cooking for her loved ones or enjoying a good chat with them. She would visit the labs and instantly get chatty about the latest advancements in the field as she did 30 years ago with students whom she just met for the first time. She made them feel at ease and talked about how they were lucky to use the advanced technologies that she never got to use. One can only imagine her joy if she knew about the new nanopore sequencer installed in the department.

She never let her age catch up with her and was lively till she succumbed to her sickness. Her deep sense of care for her students was evident as she continued to keep in touch with them, visit their labs etc. She found joy in just knowing that something new is discovered or developed every day. Her passion and intuition for learning were so strong that she would have done complete justice to every era of science.

Before I try to write down about my association and my learnings with Prof. Sandhya Mitra, I must admit that words will fall short of in describing her larger than life personality. Thinking about her, I am filled with awe and wonder about how fueled with passion and energy a person could be to achieve so much in so many fields, be it academics, music, dance, literature, crafts, painting, cooking, sewing, knitting etc.

She was far ahead of her time. Her progressive thoughts and blunt remarks reflected her convictions. She was a voracious reader who read the literature of all genres.

Until her last visit to Pilani at the age of 87, she would go to the library, bring books, research papers, read them and then sit erect on the dining table, pouring her understandings on sheets of papers in her bold handwriting. It was a sight to see her absorbed fully in reading and writing. Every visit to Pilani she would go to Biological Sciences Department and visit the genetics lab that she had founded. She would also interact with faculty while sitting for hours with Prof AK Das and Prof Manoj Kannan. She published 5-8 textbooks in molecular genetics after she retired in 1992 from the academic world, the last one was published in 2013-14. She would draw intricate pictures by her hand in a way, easy to understand.

She was an amazing storyteller who travelled widely and had friends and associations from a wide spectrum of professions. She would express her experiences, opinions, insights and foresight with great detail. She deeply cared for her students as they had become her extended family. She invested so much of herself in their wellbeing that she was like a mother to them. I would often see students recuperating in her home.

She had a great role in my upbringing. My father was the personal secretary to her husband Dr CR Mitra - an architect of BITS Pilani. All the choices with respect to flexibility in academics, academic regulations, practice school integrated learning program, extra and co-curricular activities are his brainchild. He was a visionary thinker, far ahead of his times and dedicated the prime of his life to lay a strong, radical foundation of the BITS system of education. She was very proud of her husband and his achievements, contributions in making BITS what it is today.

I called her masima/mausiji. Their daughter Anuradha (Mumu) was my first friend and continues to be my special best friend. During summer vacations she taught us embroidery, introduced us to the world of English classics like Little women, Black beauty, made us watch movies; Sonar Kela, Pather Panchali and listened to Ravinder sangeet. I am still fascinated by the dresses she made for her daughter Mumu, long flowing stylish frocks, which she embroidered.

Mumu's birthday was something I looked forward to every year. We were treated with home-baked cakes, pizza, pancakes and played games. I never knew about birthday celebrations before this. Their son Amitava (babi) is like my brother. We have had very strong family bond. She treated my father as her elder brother. She would take Mumu and me to the cottage industry at Janpath and to all state emporiums in Cannuaght place to develop in us an appreciation for handicrafts. I owe to her my love for handicrafts, music, painting, reading, literature, etc.

I also learnt from her the virtue of gratitude; acknowledgement of the services provided by one and all. In every visit to Pilani, she would go to homes of all the helpers in her home-. cook, driver, cleaner, and would bring gifts for them and would be so happy to learn about their children and grandchildren settling well, successful in life.

I can never forget my visit to Barcelona, where she stayed till the end with mumu since 2009. She drowned us with excitement, warm welcome and affection while introducing us to her friends who came to meet us and took us to her favorite cafes. She loved all kinds of food and would write down recipes for whatever she liked. She was also working on a cookbook with easy and quick recipes.

I miss her intimate long messages where she shared the nitty-gritties of her life on Facebook and WhatsApp.Her landscape of life is vibrant wide and rich. She lived life fully, faced all challenges with grit and guts and brought glory to all her tasks.

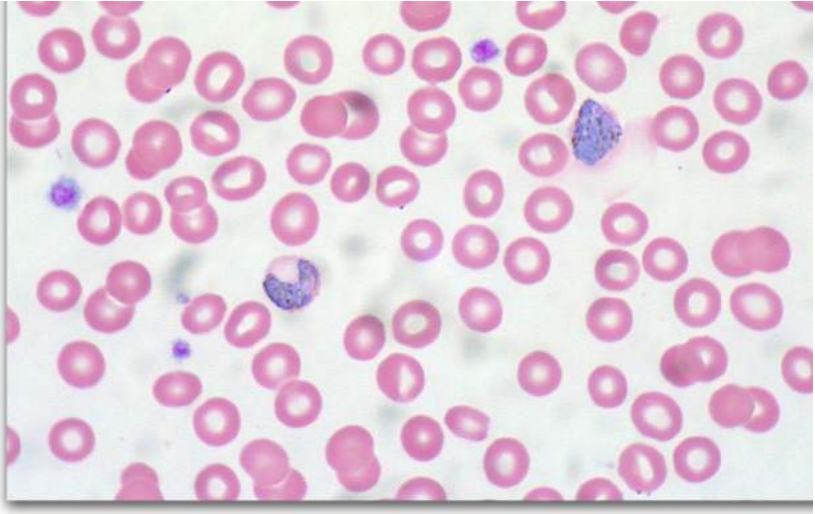
Love you and miss you masima. There can not, will not be another one like YOU.

Writen By Dr Surekha Bhanot, Professor at BITS Pilani.

She authored five books, including a revised edition (published in 2015) of her popular book, Genetic Engineering : Principles and Practise. Through these books, Professor Sandhya Mitra will continue to guide and inspire students for long. She lived every day to her fullest and has left a permanent imprint in all our hearts and in the chronicles of science.

Written By: Aryahi Anil Kumar.
This article would not have been possible if not for the contributions of :
Dr AK Das, Professor at BITS Pilani.
Dr Gora Datta (Pilani '84)
Dr Anand Chandrashekar (Pilani '87)
Dr Purnanda Guptasarma (Pilani '88)
Dr Ganesh Anand (Pilani '92)

Research in Pilani: In talks with Dr. Vishal Saxena



Working With *Plasmodium vivax*

Dr. Vishal Saxena, Associate Professor, Department of Biological Sciences, BITS Pilani was intrigued by the fact that *Plasmodium vivax* was reported way back in late 1800s, but no vaccine exists till date. He has been doing research in this area for 18 years now and has found some mind-blowing facts about the parasite. He is currently working on the plastid like organelle in Plasmodium vivax called as Apicoplast. They were the first group to report complete sequences of some major coding regions from *P. vivax* apicoplast genome and they have also characterized its differences with those from *P. falciparum* and other *Plasmodium* species apicoplast genomes. They have also reported major proteins from apicoplast of *P. vivax* that may be considered as putative drug targets in the parasite. The apicoplast is an important organelle for the parasite and one can kill the parasite by just knocking out this organelle.

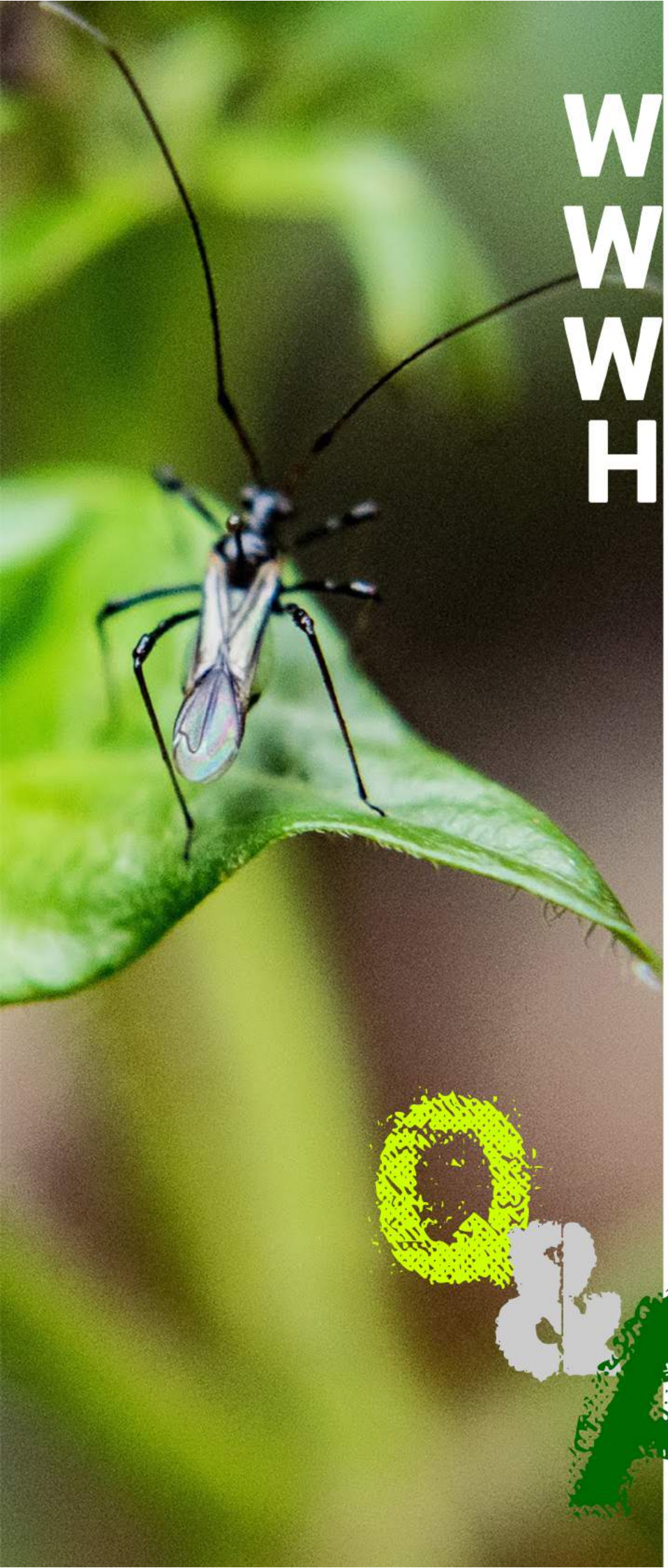
Plasmodium is a unicellular protozoan parasite and the cause of malaria in humans. Malaria is a significant global problem. According to WHO World Malaria Report 2018, there were approximately 219 million cases of malaria globally including about 435000 deaths in 2017. Five species of parasite are known to cause malaria in humans and two of them, Plasmodium falciparum and *Plasmodium vivax* account for the majority of cases.

When female *Anopheles* mosquitoes bite a person, it releases the parasite into his blood. Sporozoites are the first form of parasite that comes in blood and invade liver cell. There the parasite cells divide mitotically, and each may give rise to another 50-200 of daughter parasites. Once in good numbers, they rupture the hepatocytes (epithelial cells of liver) and infect RBCs. *Plasmodium vivax* can only infect immature RBCs while *P. falciparum* can infect all kinds of RBCs. Also, one astonishing feature of *P.vivax* is that, if it enters inside the liver, it can stay there for several years in an inactive form called hypnozoites and might become active again anytime later during the lifetime of the patient. The precursors for this activation are still unknown.

It is difficult to study *Plasmodium vivax* because it can infect only immature RBCs called reticulocytes which are very less in number (about 5ml in a 350 mL pouch of blood). Also, not a single lab has been able to perform a long term in-vitro culture of *P. vivax* for more than 2 weeks and that is also in the most advanced labs. After 5 – 7 days the parasite cannot survive. All these factors make in-vitro culturing and all related studies to identify novel drug targets or to genetically modify the parasite major bottleneck in the research of this parasite.

Dr. Vishal has worked in collaboration with clinicians. His lab has expertise of working with RNA/ DNA/ proteins of the *P. vivax* parasite.

Written by Muskan Kansal
And Aditya Choraria



What?
Why ?
When?
How?

Why Do Mosquitoes Buzz?

The buzz by the mosquitoes which is produced when they fly is not the sound of the wings flapping against the air but of an organ at the base of their wings which makes it. Scientists have discovered that when males and females flew nearby, they altered the pitch of their buzz to match each other, and if they matched well enough, they mated.

Q&A

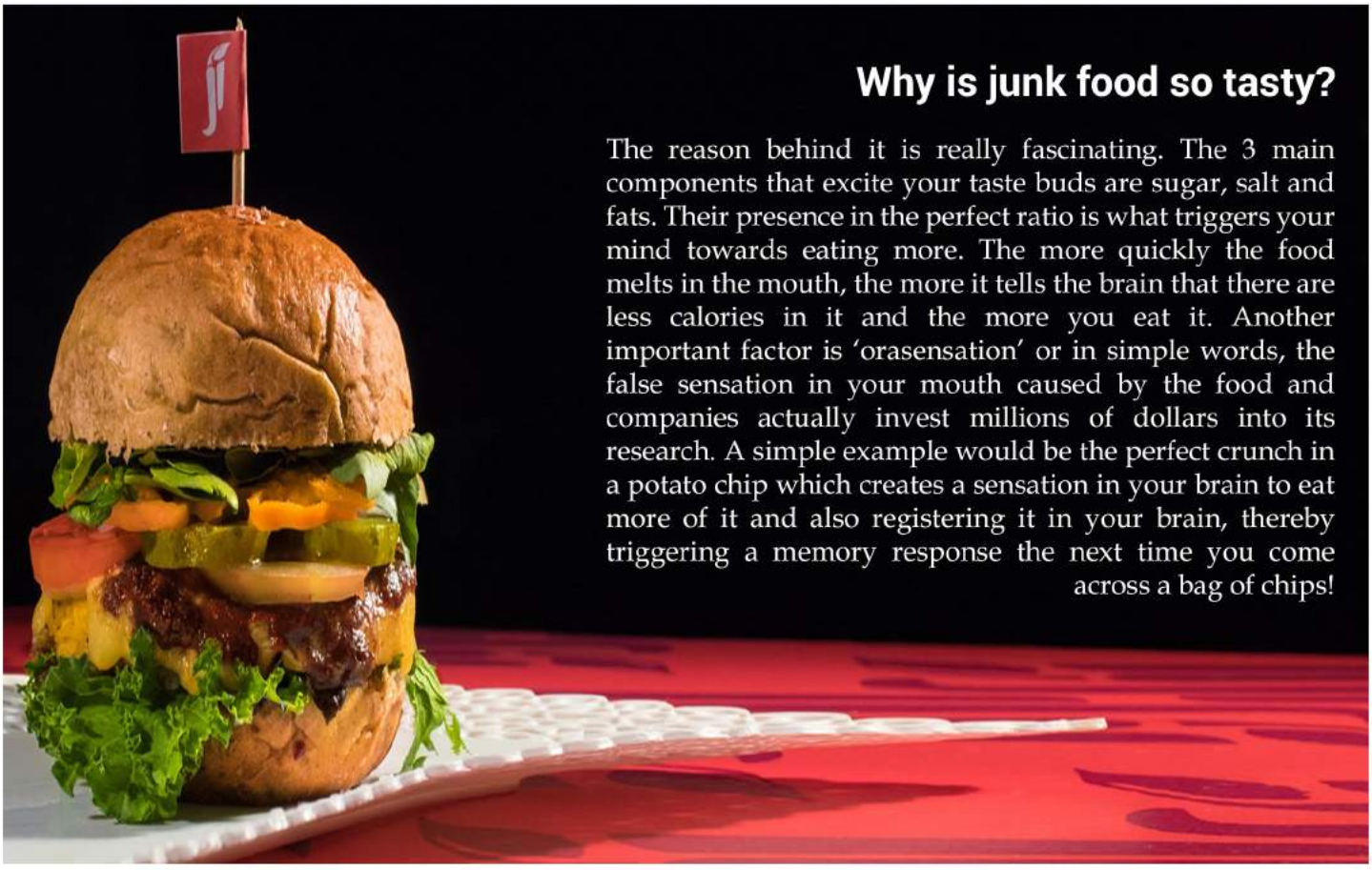
Why do we laugh when tickled?

Our most ticklish parts are coincidentally our weakest spots, such as the neck or stomach. So scientists have theorized that parents in earlier days would have tickled their offspring, training them to react while in danger and that the laughter of tickling is an acknowledgement of defeat. Tickling has thus evolved to encourage the development of combat skills. "Tickling laughter" and "plain laughter" are different as tickling stimulates the hypothalamus, which controls reactions of fight or flight. When you tickle someone, you actually stimulate the unmyelinated nerve fibres that cause pain. This also explains why you can't tickle yourself - your brain is aware that there is no need to produce a response to the action.

Why are yawns contagious?

We almost always have a tendency to yawn when we look at someone else yawning, or even pictures of yawning people.

This is mostly because the act is linked to mirror neurons. They compel us to mimic the activity without thinking and decide "this behaviour must be useful, so I better do it too." This is also termed as social mirroring and can be perceived as a way of social communication, the way you smile when someone else does. These neurons not only help us learn motor actions by observation but also play a role in anticipating and predicting the behavior of others during social interactions.



Why is junk food so tasty?

The reason behind it is really fascinating. The 3 main components that excite your taste buds are sugar, salt and fats. Their presence in the perfect ratio is what triggers your mind towards eating more. The more quickly the food melts in the mouth, the more it tells the brain that there are less calories in it and the more you eat it. Another important factor is 'orasensation' or in simple words, the false sensation in your mouth caused by the food and companies actually invest millions of dollars into its research. A simple example would be the perfect crunch in a potato chip which creates a sensation in your brain to eat more of it and also registering it in your brain, thereby triggering a memory response the next time you come across a bag of chips!

Love and Heart, are they related?

Let's start with the physical feeling of love. It no surprise that we tend to associate the symbol of a heart to our loved ones. When you see the love of your life, your body releases dopamine, adrenaline and norepinephrine which leaves your heart starts fluttering and flip-flopping and the beats are like out of the world. This might even get one thinking 'Oh, wow! That's my heart! And it's telling me that I'm in love!' Well there is a science between why it behaves this way - being in love can elicit the same flight-or-flight hormones that make the heart beat faster and stronger so we can run away from danger though there is nothing to be afraid of (or is there?). At the other end of the relationship or when your favourite toy breaks, you feel sad and empty in your heart and you suffer from what scientists call a 'Broken Heart Syndrome'. Scientifically what is happening is you get this huge sympathetic surge of hormones that stuns the heart, and it stops functioning properly.

What causes jet lag?

The answer lies in the fact, that our body has a well customized internal clock, called the circadian rhythm whose major function is to decide what time we sleep and wake up.
When we take long airplane journeys, we change a lot of time zones, but our internal clock is synchronized only with our homely time zone and doesn't account for the change of it with distance. Thus, you end up experiencing jet lag. Therefore, the more the time zones you cross, the more intense your jet lag is going to be.

Why do we get "goosebumps" when we feel cold?

Goosebumps are a physiological phenomenon inherited from our animal ancestors, which was useful to them but are not of much help to us. These bumps are caused by a contraction of miniature muscles that are attached to each hair. Each contracting muscle creates a shallow depression on the skin surface, which causes the surrounding area to protrude. The contraction also causes the hair to stand up whenever the body feels cold. In animals with a thick hair coat this rising of hair expands the layer of air that serves as insulation. The thicker the hair layer, the more heat is retained. This reaction is useless to us because we do not have that thick hair coat, but goosebumps persist nevertheless.

Why do our toes and fingers wrinkle after a bath?

Researchers have known since the 1930s that wrinkling of skin after exposure to water doesn't occur when there is nerve damage. This led to the conclusion that it happened due to an involuntary reaction by the body's autonomic nervous system. In fact, the distinctive wrinkling is caused by blood vessels constricting below the skin.
But why? As it turns out, wrinkled fingers provide better grip when handling wet objects. They can be thought of as the rain treads in car tires which allow more of the tire to be in contact with the road giving it a better grip. It is believed that these wrinkles helped our ancestors gather food from wet vegetation or streams making this more of a vestigial relic.

Why can't dogs eat chocolate?

Chocolate has a compound named theobromine. Theobromine along with caffeine are some of the compounds present in chocolate that entice us to consume it. When humans consume chocolate, these compounds cause our heart to pump faster, our blood vessels to dilate and helps our muscles to get more energy. But an accumulation of theobromine can cause our heart to pump way too fast leading to muscle convulsions, heart attack and even death. But wait, people don't die of a chocolate overdose, do they? Thankfully for us, our body can process theobromine pretty quickly and its levels are low enough to not cause any harm. Unfortunately, our pets aren't so lucky and theobromine stays in their system for a considerably long time and cause harm. One main reason for this difference in theobromine processing could be because our ancestors relied on plants for their survival for a very long time unlike the ancestors of our pets like dogs and cats.

Why Do I See Patterns When I Close My Eyes?

Many people who have seen this visual phenomenon think it is a light-induced afterimage of what they had seen before they closed their eyes, but an afterimage might only be a part of what they are seeing. The real reason we are treated to this fuzzy fireworks display behind closed lids has to do with phosphenes! Phosphenes are the moving visual sensations of stars and patterns we see when we close our eyes. They are thought to be caused by the inherent electrical charges the retina produces even when it is in its "resting state" and not taking in a ton of information and light like it does when our eyes are open.

Why do camera flashes make your eyes turn red?

Camera flashes do not make your eyes turn red. The inside of your eyes is always red. The bright light of the camera flash just makes the colour more obvious. Your eye is essentially a hollow ball filled with clear fluid. The hole at the front of your eye, the pupil, lets light into the hollow space inside the eye. The light passes through this space and then strikes the inner back surface of the eye, known as the retina which is supplied with an enormous amount of blood which gives the red colour.

How do Anesthetics work?

Inhalable anesthetics disrupt structures in the cell membrane called lipid rafts. Lipid rafts are dense structures made of fat molecules like cholesterol. When an anesthetic is introduced, the components of the lipid rafts drift away from each other and cause something similar to an expansion. The process is similar to billiard balls, which move away from the center when hit with the cue ball. When these lipid rafts expand, they burst and spill their contents. The enzymes released have the power to change the potassium concentration gradient by interacting with certain proteins that make up ion channels in the cell membrane. The potassium gradient is essential for the proper functioning of the neuron. Its disruption causes the neuron to be inactivated for a while until your cells' natural mechanisms restore the balance.

ALUM TALK

Dr. Sridhar Ramanathan, from the batch of 1992, is currently with NIRAMAI, a healthcare start-up that engages in AI-enabled detection of fever and COVID-19 related respiratory symptoms. He was the President and CTO of HealthCube and the Site Director of the Bangalore Development Centre of the Beckman Coulter Life Sciences. Here is an interview where we discuss his journey from college to establishing himself in the bio-medical industry.

What motivated you to opt for a PhD in Analytical chemistry?

I majored in Instrumentation and Chemistry at BITS Pilani. Analytical Chemistry is a mix of these two. I further pursued bioanalytical chemistry which essentially deals with biological sensing systems. Developing new sensing tools was a convenient overlap considering that instrumentation was about developing the systems and analytical chemistry was about identifying the targets.

After a PhD in Analytical Chemistry, how did you switch to product development in the later years of your career and then to a biomedicine based start-up?

During my PhD, I was the first student under my advisor and was involved in academic and non-academic activities including the recruitment of students. I was involved in multiple projects and had nearly 20 publications by graduation. I returned back to India in the year 2000 and joined GE India Technology Centre, Bangalore. I was offered a million dollars to set up the laboratory there. It was a completely new venture as it was not in line with my work during my PhD.

After that, I transferred to an area called Six Sigma where the application of statistics and optimization was required. I do wish I paid more attention to the course during my years at BITS. After a while, I wanted more action, so I then switched to a start-up at TVS, an automotive company.

As BITSians we are exposed to everything as a part of our learning. I met with the president of FORD and they couldn't guess my degree. Simply because we know enough to talk to people. After some years, I was introduced to a company called Rea Matrix which dealt with medical technology. I was under the mentorship of Bala Manian who was a phenomenal entrepreneur. As a mentor he exposed me to a wonderful learning experience.

HealthCube is commendable and a need of the hour start-up. Could you give us an insight into developing innovative and accessible healthcare products?

HealthCube is also a BITSian startup, although I am no longer a part of it. It was founded by Ramanan Laxminarayan who is also a BITSian. The company was based in Delhi. Three years ago, I rebooted the company in Bangalore and developed some platforms and tools for the management of point-of-care and related healthcare services.

We also managed to get a CE marking, ie, E-manufacturer's declaration that the given product meets EU standards for health, safety, and environmental protection.

NIRAMAI is famous for its breast cancer detection techniques. Now they are also providing thermal detection solutions for COVID-19 symptoms in a much safer environment. Could you brief us on your work and goals at NIRMAI?

After Healthcube, I was looking forward to more, which was when NIRAMAI came along. From my observation, cancer is very common and we are losing more people to it every day. It is not as distinctly visible as one thinks it would be. Looking at the technology that NIRAMAI has, they do not come significantly from a diagnostic perspective but are from AI-based solutions. I was part of the leadership team there. But I have also worked on representing NIRAMAI for regulatory clearances.

The cases of breast cancer is increasing in all countries including India. The biggest challenge in a country like ours is that people don't come for regular medical check-ups. People are not encouraged to get to the screening despite it being very important for early diagnosis. Mammography, the X-ray based screening process can often be a painful process causing discomfort. Sadly, it was the most common screening tool and caused physical discomfort, especially for women. In countries like India, even if we offer free screenings, people don't come due to social stigma.

NIRAMAI has come up with a different solution, ie, they take thermal images of the breast and analyse it using AI. The detection is based on the physiology of cancer known, hence, the process of screening is now much more comfortable for the patient. Therefore it can be used as a way for mass screening and unnecessary deaths can be avoided.

How did you tackle failures if you have faced any and what have you learnt from them?

BITS is a place that teaches you to deal with failures. Failures will happen whether you like it or not. The way you manage and deal with them is what matters most.
One such instance from my life was when I was working at ReaMatrix. We were addressing the detection of HIV using a flow cytometer. The reagent used in the cytometer had a market value of $6. We came up with a better reagent, a dry one, which was easier to handle and cost only $3.
Once we started manufacturing, we were expecting significant sales due to the advantages that our product was offering. However, that was not the case. We discovered that people were accustomed to using other liquid reagents with the hardware.
We dealt with this situation by manufacturing our own hardware that was compatible with our reagent. Thus, you should learn from your failures and not repeat the same mistakes. If you start being afraid of failures, you will never grow. BITS grills you through an ample amount tests and quizzes. An 'E' grade doesn't mean that you failed but it means that you are exposed to the subject. Similarly, a failure exposes you to mistakes so that you don't commit them again. You can make mistakes but you should try not to repeat the same mistakes again.

"BITS is a place that teaches you to deal with failures. Failures will come your way whether you like it or not. The way you manage and deal with them is what matters most."

Your views on the COVID-19 situation in India.
What message would you like to give to the people to stay motivated and efficient in these difficult times?

At the beginning of 2020, nobody had any clue on how to deal with the situation. March is when the situation worsened and our efforts began taking off.
A personal takeaway is that we do not know much yet. We were lucky and were able to take reasonable precautions that allow us to ride it out.
The smart thing would be to limit our exposure hence giving our body a fighting chance. We should take all possible precautions from our side.
In short, there are so many things going on around us and we should handle this situation with poise and take all the necessary precautions like following social distancing norms.
We should understand the seriousness of this situation without panicking and prevent any kind of chaos maintaining peace of mind.

What advice would you like to give to a younger version of yourself?

You should make use of the opportunities that BITS has to offer and not be solely inclined towards academics. Though academics must be a priority. During my time at BITS, I was involved in theatre and made a lot of good friends and a lot of memories. And these friends have still stuck with me through the years. This is the time where one should dream big. I would describe this as similar to hitting hard for a six while taking the risk of the ball being caught in the last over in a cricket match. You have nothing to lose at this point and have zero risks. As a student, you are in the prime time of your life to explore different things. If you have an idea then you should explore it. The worst case is that you might fail but you can always move on in life and you are not going to regret it. Don't wait for too long because as you grow older your risk profile also increases. Make mistakes and learn from them but don't be afraid of failures

Written by Akshat Jain and Aaryan Charak

EPIGENETICS

The Cycle of Life and So Much More

"Oh! You look just like your mother!" This might have been a common thing you would've heard growing up and the reason for it, which is genetic inheritance, is something we are all aware of.

Does a person's actions in their lifetime also affect their progeny or at least themselves? We have another type of inheritance that might not be so commonly heard of but is gaining a lot of traction in recent years and this is the field of Epigenetics.

Written By Arpit Singh and Kirat Chawla

The term epigenetics literally means 'on top of' or 'in addition to' genetics. Epigenetics refers to the study of inheritable physical changes that are not associated with the genetic makeup of an organism and is important for the regulation of gene expression in a cell. The DNA sequence is important in determining what proteins are formed in the organism while the gene expression pattern determines which genes are allowed to express in a cell and those proteins are produced and it is because of this differential expression that the behaviour of a particular cell is different from any other.

Every cell in our body has DNA which is approximately 6ft long! DNA strands are condensed—in a process known as supercoiling — by wrapping around proteins called histones. This condensed form of DNA is what we call a chromosome. All our cells have the same DNA yet, the difference between a brain cell and a liver cell is remarkable. So, how do our cells grow to become so different? The answer is in epigenetic markers. Our DNA is so tightly coiled that reading it is next to impossible. Certain proteins called transcription factors cause-specific regions to unwind by attaching themselves to those regions. Scientists now hypothesise that the binding sites are also controlled by epigenetic markers; methylation at cytosine, and guanine dinucleotides (mCG).

Though DNA methylation—better known as covalent modification—is only one of the nine epigenetic mechanisms, it has become synonymous with epigenetics because of its wide-ranging effects. Methylation of the cytosine usually occurs when it is adjacent to a guanine residue and when methylation occurs at the promoter, which is usually GC rich, it means that the gene has been silenced as it makes the promoter less accessible to the RNA polymerase. Research has shown that this methylation pattern is heritable and gets transferred to DNA strands that have arisen from the parent strand via replication and so the effect that this methylation pattern has on gene expression is inherited.

DNA is negatively charged, compact and wraps around histone proteins. Euchromatin which has loosely packed genes is highly expressed, unlike heterochromatin which has tightly packed genes. The tightly packed heterochromatin corresponds to a decrease in gene expression due to the accessibility of the genes to the molecules required for transcription to take place. Thus, these histone proteins have an important role to play in the regulation of gene expression. Histones can undergo several modifications like methylation and acetylation that enable them to do this. These epigenetic phenomena can occur as a result of many factors like the environment, mental conditions and could also be a part of normal development. Epigenetics tells us that not all physiological phenomena can be explained by just looking at one's genome and provides a layer of context that helps usunderstand how the interaction between several genes in the right proportions has helped us develop into what our bodies have become today.

TERMS EXPLAINED

Gene Expression Pattern: A gene's expression pattern can be defined as a distribution of its products; mRNA and proteins in different concentrations in different cellular compartments.

Transcription factors: It is a protein that controls the rate of transcription; copying a segment of DNA to RNA. It binds to the DNA and either promotes or blocks the transcription of a gene.

Methylation: DNA methylation is a biological process by which methyl groups are added to the DNA molecule. Methylation can change the activity of a DNA segment without changing the sequence.

Euchromatin: Euchromatin is a lightly packed form of chromatin (DNA, RNA, and protein) that is enriched in genes, and is often under active transcription.

Heterochromatin: Heterochromatin is a tightly packed form of DNA or condensed DNA, which comes in multiple varieties. It mostly consists of repetitive DNA sequences and is relatively gene poor. Its most notable property is its ability to silence euchromatic gene expression.

Specialisation: Modification of newly formed cells so that they develop the features that render them structurally and functionally useful.

Histones: Histones are a family of basic proteins that associate with DNA in the nucleus and help condense it into chromatin.

Germ cells: Germ cells or sex cells are cells that are used by sexually reproducing organisms to pass on genes from generation to generation.

Micro-array: A microarray is a laboratory tool used to detect the expression of thousands of genes at the same time.

Oxidative stress: Oxidative stress is a phenomenon caused by an imbalance between the production and accumulation of oxygen reactive species in cells and tissues and the ability of a biological system to detoxify these reactive products.

Another term called 'Epigenetic Inheritance' is often used interchangeably with epigenetics. It is a part of epigenetics, which refers to the characters' inheritance even without a change in the genomic sequence. A great example, mentioned earlier, is the differentiation and specialisation of cells.

Even though the initial stimuli are gone, and the DNA is identical, yet these cells breed true (phenotypically identical to the parent). Epigenetic inheritance is affected by various external stimuli like mental stress or even diet. Yes, It has been found that our diets can affect our germ cells in some ways. It would mean that we are what our parents or grandparents ate! Such Methylation marks are as easily inherited as easily they are reversible.

In agouti mice, certain diseases can be reversed just by changing the diet of the mother. Mice that inherit the agouti gene are born obese and golden in colour. Such mice develop diabetes as well. Two genetically identical mice were born, the only difference being the diet of the mother. One mouse was born obese and golden while the other mouse was born lean and brown; the agouti gene was silenced in the second mouse, where the mother was given a diet that promoted methylation.

Ageing

Another interesting aspect of epigenetics is Aging. Is age just a number? Do you start dying the moment you are born, or do you start dying when you cease to grow? Our cells get old and they die but we don't get old because of our cells. New cells are created all the time, so, are these new cells any different? If not, then how do we get wrinkles? Why do our bones get weaker? Why do we lose our strength? For quite some time scientists have been researching aging.

It has been suspected that aging must occur during cell division. At the ends of our chromosomes a repeating genetic code sequence called telomere is present and it has been observed that cell division shortens the length of these telomeres, hence, a lot of research was conducted to re-enforce this hypothesis. During these researches in addition to telomeres, many other factors have also been identified which may play an even bigger role in aging. In each cell, the DNA in a semi-coiled form is attached to certain proteins, called histones. This DNA can be damaged by numerous external factors like UV rays from sunlight and this may lead to extreme damage and may lead to a shut-down cell (called senescence). Hence, a lot of energy is expended in uncoiling the DNA then replicating it to make a new cell. Replications aren't 100% perfect and this leads to some mutations in our DNA sequence after each replication cycle. It has been observed that some genetic mutations do cause thinning of hair and face looking much older.

Now, scientists are facing the chicken or the egg dilemma, as we have been unable to determine whether it is the mutations that are responsible for ageing or our replication mechanism itself becomes less efficient because of age. The latter has basis in the fact that as we get older the capacity of our body to produce hormones and proteins diminishes. Production collagen—which provides our skin its strength and elasticity—starts to decrease as we get older, leading to wrinkles. Functional studies in model organisms and humans also indicate that epigenetic changes have a huge influence on the ageing process.

Our life span is largely epigenetically determined. Diet and other environmental factors can influence our life span by changing the epigenetic information. The uncoiled part of DNA undergoes methylation as time passes, this methylation density can be studied to get an idea of relative age. But the more interesting phenomenon is when scientists put rats through procedures where their DNA was damaged to artificially induce ageing the methylation on their DNA increased as well. The role of epigenetic modifications has been extensively studied and evidence strongly suggests that the environment plays a role in ageing. Though these studies suggest that there is some sort of passing of epigenetic marks through generations, formally called transgenerational epigenetics, there is still a lot of debate in this field as most studies reveal that epigenetic marks are erased in the germ cells and so the mechanism for such findings is still unknown. However, within the individual's own somatic cells these changes do remain and are stably inherited. A study published in the American Journal of Clinical Hypnosis studied the effects of therapeutic hypnosis on gene expression. The participants of the study were subjected to therapeutic hypnosis and the effects of the therapy on their leukocytes were studied using DNA microarray technology and some bioinformatics tools.

What the researchers found was that there was an upregulation of genes characteristic of stem cell growth, a reduction in cellular oxidative stress along with a reduction in chronic inflammation further strengthening the theory that therapeutic hypnosis can transform ideas into acts in receptive subjects. Apart from modifications on a cellular level, modifications, changes on an organism level like a better lifestyle has pointed towards slower aging. Stress has been linked to the shortening of telomeres in the cell and other epigenetic modifications which induce the effects of ageing. As is illustrated by this study, epigenetics allows us to see life in a much more hopeful manner wherein we have a lot more control than was previously believed when a lot was attributed to our genetics and accepted as is. A healthy lifestyle and environment are believed to correspond to a good epigenetic pattern.

Although we cannot single-handedly control our environment, we can take steps to improve our lifestyle by having a healthy diet, engaging in regular exercise and by taking care of our mental health. Hence, it is possible that ancient yogis lived a lot longer because yoga and meditation or somras was a drink that could slow down these modifications on a cellular level to lengthen the lifespan. Maybe one day we will be able to live a healthy life way past 100 years. Will that be a good thing or not more discussion needs to take place to decide that. Will we become immortal? Is there even a point to living without death? But the point of research like this is not to answer these questions, they are just a conduit to satisfy human curiosity. They are a means to understand ourselves better, the more we know that we get enamoured by the sophistication that millions of years of evolution have brought about.

Photo by Rod Long

Addiction

Is it easier for some people to get addicted than others?
Scientists did an experiment where mice were rewarded with cocaine for sixty days (a full cycle of spermatogenesis). It showed that their offsprings had less susceptibility to becoming drug dependent. Addiction has been linked to the acetylation of histones in the neurons and the increased expression of a gene called BDNF. The changes the offsprings experienced are hypothesised to give an evolutionary advantage. If an organism can quickly adapt to its environmental changes, it has a higher chance of survival. Now that the addiction markers have been identified, there is a possibility to cure addiction clinically in the future.

Anxiety and Stress

Mother's love is pure and unconditional. Does this love play a role in the early development of the child?
One of the earliest experiments in the field of epigenetics was the mouse pup licking. Researchers found that the pups who were licked and pampered more frequently handled stress and anxiety much better later in their lives than those who weren't looked after by their mother mice. This behaviour was independent of the mice's lineage. When the mice from the loving mother and the inattentive mother were exchanged, the end results remained the same. This experiment was the first major breakthrough for epigenetics and is still widely quoted everywhere. It introduced the masses to the idea of epigenetics.


Photo by Luis Villasmil

Lamarck's Hypothesis and Epigenetics

Jean-Baptiste Lamarck was a French naturalist. He gave the theory of 'The Inheritance of Acquired Characters' in 1809. His theory on evolution suggested that organisms evolve throughout their lives to adapt to their environment, and their progeny inherit these changes. This theory was completely sidelined when Darwin gave his theory of 'Evolution by Natural Selection' in 1859. Now, Lamarck's theory of evolution is experiencing a renaissance after evidence of epigenetic inheritance were discovered. Even though Lamarck's ideas weren't based on epigenetics. Still, his ideas are similar enough that the scientific community is revisiting them.


Photo by Eugene Zhyvchik

Pseudoscience

Epigenetics, as a concept, is starting to become more and more mainstream. For such a new field of study, it is both remarkable and dangerous. Certain gurus are promoting epigenetics as the answer to every biological mystery. We are in the early stages of all the research, and a lot more understanding is needed to say or predict anything. If the trends keep up, 'Epigenetics' can very well become the 'Quantum' of biology, a MacGuffin capable of explaining anything and everything. Hence, it is necessary that everyone gives this field some time to breathe and wait till more substantial results come out.

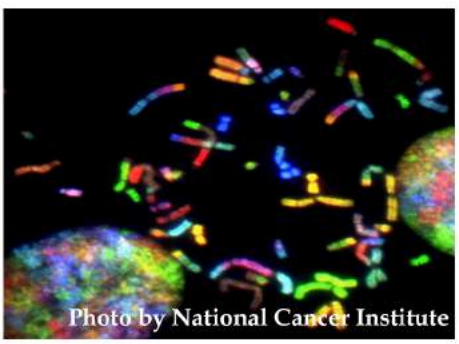


Photo by National Cancer Institute

LIFE ON VENUS

In a paper released on 14 September 2020 in Nature Astronomy, astronomer Jane Greaves at Cardiff University and an international team of scientists announced the presence of phosphine in Venus's atmosphere. Phosphine is considered a 'biosignature' - molecules that are strongly associated with the chemistry of life. However, phosphine does have a few non-life methods of production, particularly on a rocky planet like Venus.

The presence of phosphine gives an indication that there could be life in Venus' atmosphere. There are regions of Venus' upper atmosphere that are remarkably temperate and relatively hospitable. Scientists have been hypothesizing that microbial life forms could be floating around the planet for decades and the detection of phosphine supports that hypothesis.

Looking at all the possible methods of natural phosphine creation on Venus such as the production by lightning, delivery by meteorites, and photochemical reactions in the atmosphere, the scientists found that all these would produce far less phosphine than observed. The science team admits that if no chemical process can explain the presence of phosphine within the upper atmosphere of Venus, then it must be produced by a process not previously considered plausible for Venusian conditions, which could be unknown photochemistry or geochemistry, or possibly LIFE. Also, the detection of a single biosignature does not mean life has been found on Venus. We must learn to embrace the uncertainty and to resist our desires for a binary answer—life or no life? - while the process of science does its work.

Written By Srimit Sritik Das

Dr Chandrasekhar Nair received his Bachelors' and Masters' degrees in Chemical Engineering from BITS Pilani during the 1985-91 period. He earned his PhD degree from the Vellore Institute of Technology in 2016, for his research involving the development of near-care portable molecular diagnostics for infectious diseases. He is a founding director of Bigtec Private Limited (since 2000) and Molbio Diagnostics Private Limited (since 2011), and is also the Chief Technical Officer at Molbio Diagnostics. The Truelab portable RT-PCR diagnostics platform developed and commercialized under his leadership has had a tremendous impact on point-of-care diagnostics of tuberculosis and other infectious diseases in India. It is the only such indigenously-developed portable molecular-diagnostics platform that has been approved by the ICMR (Govt. of India) and recommended by WHO, and can be used in even remote healthcare locations without reliable power supply.

Could you tell us about your transition from chemical to the field of biomedical sciences and the factors that influenced this transition?

Even as a student, I had friends from multiple branches, whether it was computer science or physics or mechanical.

This environment shaped me to have an appreciation for other disciplines. It also taught me that there can be multiple ways of looking at a problem. Subsequently, when I was doing my masters, I had the opportunity to work with people working in the field of bio-sciences, on many multi-disciplinary projects. This experience opened up the possibility of bio. I had always liked biology but unfortunately, I hadn't pursued it after 10th.

When I finished my masters, I had almost joined bits for PhD, but then an advertisement from Vittal-Mallya Scientific Research foundation asking for modelling and simulation of distillation columns caught my eye.

When I finished my masters, I had almost joined bits for PhD, but then an advertisement from Vittal-Mallya Scientific Research foundation asking for modelling and simulation of distillation columns caught my eye. The project was on one of my favourite topics. Unfortunately by the time I had joined, the project had moved from Bangalore VSRF to IIT KGP. So, I was told to look at recombinant fermentation.

I had to learn about DNA and RNA all over again and understand what recombination is. We were the first in the country to work on recombinant insulin. I had very good training at VSRF and did fantastic work on fermentation. This started my journey into the multidisciplinary field.

As my career progressed, I started looking on how to scale up lab processes and moved into techno commercialization.

Around this time, a friend from BITS during my masters approached me, with an opportunity in IT and the emergent fields of life sciences. This was exactly the kind of thing I wanted to do. The team had four of them with an IT background and I had a mixture of life sciences and chemical engineering. We set up our company that focuses on diagnostics and point of care, using state of the art technology. I was a bench researcher and did a lot of work on PCR and was very fascinated by it. Mainly because as an engineer we are taught that specificity and sensitivity don't go hand in hand, but here, PCR was a technique that required both. At that point in time, there was almost no use of PCR as a diagnostic tool, primarily because you needed a PhD to even run a PCR because it seemed fairly sophisticated.

It took us several years to get a hang of it and to get relevant results. Once we did, we started looking towards making the technique mobile. My dream was always to see a lab that would reach my village. When you have a team, which is capable of looking at the same problem from multiple angles and training in different disciplines to try and solve a problem, you grow.

ALUM TALK

What goes into the ideation of diagnostic products and how does it become from an idea to a product?

PCR for point of care incolves ensuring that it is very rapid. Many people don't reach out to healthcare unless you can diagnose or treat them within the same visit. This requires a very efficient, precise and presumptive diagnosis. The technician and the infrastructure requirement needs to be minimal. We also had to make the product affordable. So, these were the goals that we set for ourselves. We started with silicon, as the material for our product based on previous reports. We ran around a lot for the silicon chips.

PCR explained

PCR involves the amplification of DNA in vitro, that is, in a test tube allowing even a small amount of DNA to be enough for diagnostics and testing. DNA is like a fingerprint which is different for all organisms. Similarly, even pathogens including viruses have a particular DNA sequence. This allows them to be detected as they can be differentiated. PCR can selectively select for this DNA even when it is in small amounts. Our cells make copies of our DNA by the process of replication so that they can divide further. PCR achieves the same by an ingenious method so that it can be done outside our body.

The strands of DNA are separated from each other so that DNA polymerase, the enzyme which starts this process can attach to it.

This requires primers that are short stretches of nucleotides to attach at the start of the DNA.

The specificity of PCR comes in here wherein depending on the DNA that needs to be amplified, primers are designed.It is also sensitive in that if the conditions are optimized such as primer length, temperature, and concentrations, even a small amount of DNA is enough for it to be detected and amplified.

To improve the specificity and sensitivity of the reaction, as the talk mentions, silicon and ceramic chips were used. These give a surface for the reaction on which integration of a lot of thing including heat sensors could be done to improve the reaction speed. Nanoparticles were also used as they allow rapid cooling and heating, a process required for each cycle of PCR. This makes the tool a rapid as well as mobile one.

At that time a semiconductor laboratory in Chandigarh was the only place with an accessible MEMS foundry. This made it clear that silicon as a substrate for chips was not going to work, as we did not have a sufficient number of silicon foundries.

That's when one of my colleagues came up with the packaging materials that were used in space for embedding electronics - low temp co-fire ceramic. Ceramic is essentially glass and glass is great for biology. It also allowed us to use heaters, embed temperature sensors, provide surfaces that could heat and cool very fast and uniformly. This gave us early success in the lab. Then we went to the Council for Scientific and Industrial Researchers (CSIR) programme The New Millennium Indian Technology Leadership Initiative (NMITLI), the brainchild of Dr. Abdul Kalam, initially funded. We were among the first Indian companies to be funded with a soft loan from CSIR and that's how we were able to start.

We bought nanoparticles and used them, they cost around Rs.3000 per reaction.

But this was not scalable. So, we created magnetic nanoparticles, coated them and characterized them. By that time India's capability to manufacture them had increased tremendously. So we could do nanoparticles-based sample preparation. The only problem was once created they required manual pipetting. It took ½ hour and the technician was tied to it for that time. It was the first product we took to market, but labs are busy places and they don't have the time or technicians to pipette. We were finding a means to automate it, but that would increase the cost and maintenance. We decided to think big, and came up with nanofibers making our model very versatile.

An extensive study conducted by PathLabs, Seattle compared 5 different preps out of which ours was deemed to be the best at point of care sample preparation.

This was possible thanks to countless optimizations in the heating/cooling process of PCR. We were able to amplify nucleotides while reducing the contamination in the sample. Coupled with its ability to run on batteries, the sample preparation device (TruePrep) is ideal for field use and is able to extract nucleic acids in the sample in about 20 minutes. The extracted nucleic acids can then be used for PCR based diagnosis using the PCR machine (TrueLab).The entire process of sample prep + PCR usually takes about 30 to 40 minutes.

The machines can also be designed based on the desired throughput with multiple bays each capable of holding and treating a sample. They have been installed in many places in the country as well as in 31 countries around the world.

The idea of the product journey fascinates me. Especially how we managed to survive by the skin of our teeth, through all those years even when we had zero revenue. It makes me thankful for my team who have persevered to create a world-class product. Today, the product is patented in 120 countries. It is possibly India's most patented product.

What were the challenges faced by your team while catering to a huge demand for kits and testing equipment during the pandemic?

To answer your question, I have to talk about our work in Tuberculosis. With the help of Officials from CSIR and ICMR, we were able to set up a similar testing platform where we had to use sputum samples to detect Tuberculosis. Sputum samples were difficult to handle because they vary in consistency and are affected by temperature.

Furthermore, they contain some of the most powerful inhibitors of the PCR process. We spent a lot of time optimising the sample preparation techniques for sputum.

A significant amount of work went into remodelling the machines to

suit these needs. Initially, India had decided to implement these devices in about 100 locations.
At the end of December 2019, after approval from the WHO, the Government of India had instructed us to install about 1500 devices all over the country.
Thus, we were already in the process of scaling up when the pandemic hit the country. We were able to get a diagnostic test up and running. With ICMR's help, we were able to validate the test. However, the problem was that the global supply chain was badly affected by the pandemic and it became hard to procure electronics. Even simple components like capacitors and resistors were not readily available as India does not manufacture such things.
However, despite this, we were able to make 2000 devices and perform over 4.5 million tests for COVID. Testing will need to be increased due to the sheer number of people we have in our country. The only measures we can take are the early detection of the disease and preventing its spread. Luckily for us, India had about 13 locations when ICMR first approved testing. However, the TrueNat platform is 2000 strong and is spread throughout various regions of India and therefore, is able to cater to and reach out to many people when compared to laboratory real-time PCR.

We are happy to be part of this process but it shows us that we need to strengthen our healthcare systems in times of relative calm and not during extreme urgency.

Is you would like to share with future aspirants wanting to pursue this field?

In our times, no one would support you. We established our company using internal funding from other businesses. Now, the Government of India has many grants in place that supports and helps to propagate innovative ideas and products.
Innovation is already established as a process and support for innovation is already entrenched. The only thing that is not readily available is a means of easy scalability but that is a whole chicken and egg situation. Optimised manufacturing technology is seen only in places that need a large quantity of the product to be manufactured. As higher-end technologies flood the market, our manufacturing technologies would also mature accordingly. If you have an idea, now is the time to go after it.

What is the importance of an interdisciplinary mindset in today's scenario?

It's simple. You have a problem, and you need to find a solution. The solution does not have to have a tag saying that it's from a particular field, say biology or chemistry. Many problems require us to use the best available knowledge from all fields in order to come up with a solution. If you look at the case of COVID, research in physics is enabling scientists to detect COVID using different methods than those typically used in a pathology lab.

What advice would you give to your younger self?

Every class teaches us something important. There is nothing that one completely ignores. Every single moment is a learning experience. I wish I had paid more attention to my classes then. I had no clue I would be doing something like what I am doing today. I didn't even know that I would come back to BITS to do my masters. I knew very few people who were sure about their goals. I think you have to enjoy yourself and immerse yourself in multidisciplinary learning. Things automatically happen from then; life always has a plan.

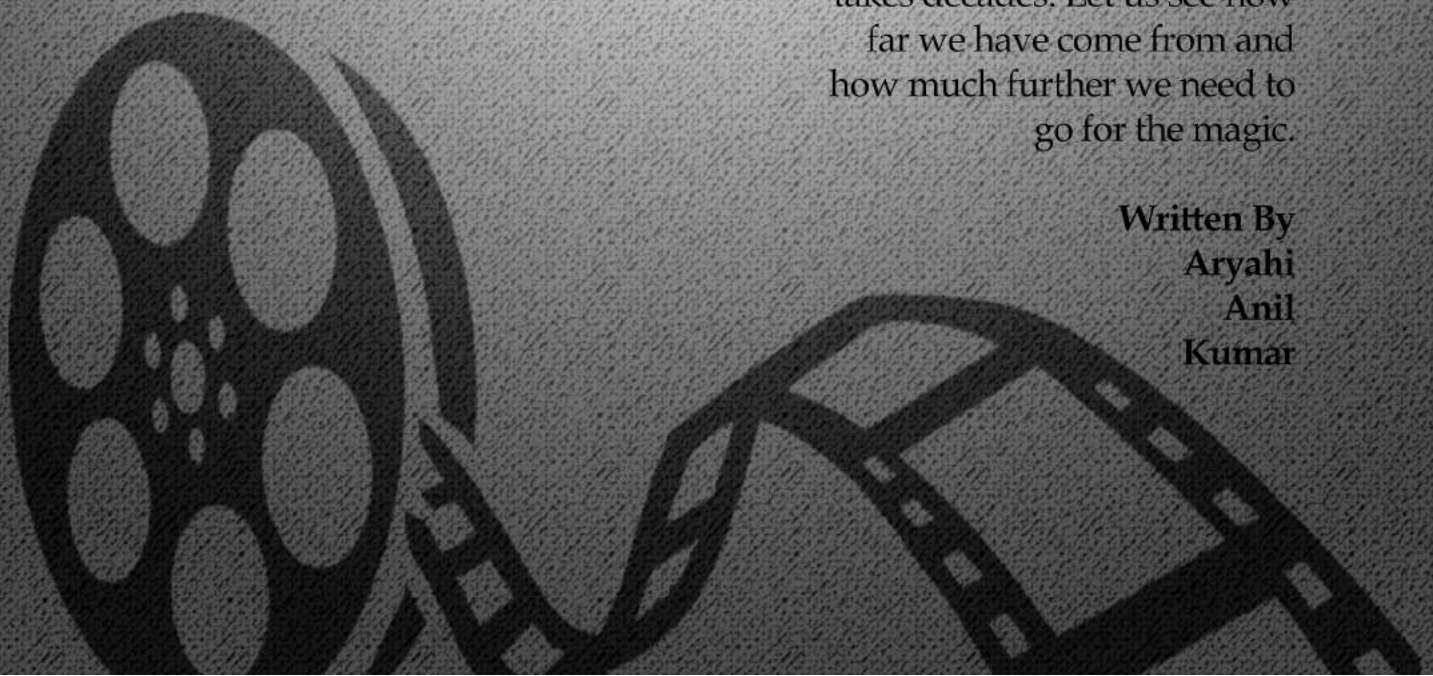
After the start of the COVID-19 pandemic in March 2020, the TrueLab platform was rapidly modified and tested for screening and confirming the presence of the SARS-COV-2 virus in patient samples through the development of Truenat Beta CoV E-gene screening assay and Truenat SARS-COV-2 RdRp gene confirmatory assay. In September 2020, it was approved by the Indian government for comprehensive RT-PCR testing of COVID-19. Subsequently, over 2500 Truelab workstations have been widely deployed throughout India (at 1008 sites in 530 districts) for rapid RT-PCR tests of COVID-19. In recognition of this tremendous contribution during his ongoing public health crisis, Molbio Diagnostics Private Limited was recently honoured with the Biospectrum Excellence Award.

Writen by Muskan Kansal and Venkateshwaran

The Science Behind The Movies

How far are we from Gattaca's (1997) genetic perfection or building dinosaurs like those in Jurassic Park(1993)? Is *'quantum science'* the 21st century equivalent of the word *'magic'*? Are scientists magicians with a pipette and electron microscopes instead of wands? Science with a twist of fiction has inspired many young minds to set off in pursuit of waving their wand one day. However, this wave probably takes decades. Let us see how far we have come from and how much further we need to go for the magic.

Written By
Aryahi Anil Kumar



GATTACA

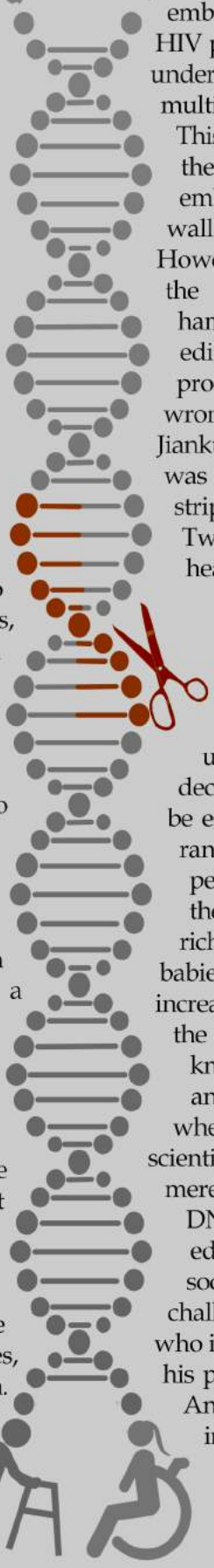
Directed by Andrew Niccol, 'Gattaca' was a film way ahead of its time. Not only does it explore the limits of science but also raises questions about the ethics of such practices. DNA of an organism holds the information for its development, growth, and death in the form of genes. The movie explores the possibility of modigying DNA while family planning to produce so-called perfect humans. This is accomplished by removing genetic defects and modeling bodies with superior physical and mental capabilities. Eugene's character in GATTACA refers to eugenics, a major theme in the movie that involves practices that aim to 'perfect' the human race and exclude people with the supposed inferior phenotypes or genetic characteristics.

What is gene therapy?

Scientists have identified more than one thousand genes that make individuals susceptible to certain diseases. Gene therapy is the practice of modifying the DNA inside cells to cure disorders. In certain cases like cystic fibrosis, the individual does not have a functioning CFTR gene. Gene therapy can be used to place the correct sequence of DNA into the cells, thus enabling the lungs of the individual to function properly again. In gene therapy for certain cancers, a gene that can cause the cancer cells to self destruct or stop it from multiplying is inserted. The common tools for gene therapy, include CRISPR-Cas, zinc-finger nucleases, viruses and TALENs. The first trial for gene therapy was in 1989, where a virus was used as a tool to cure severe combined immunodeficiency, a rare genetic disease.

Perfect Humans?

Perfect humans would mean altering genes to remove any disabilities caused by the genetic makeup of an individual, these can include disorders as common as myopia and heart diseases to downs syndrome. In certain cases, modifying your genome might even make you less susceptible to viruses like HIV. In the last three decades, scientists have identified multiple genes linked with disorders like heart diseases, diabetes, obesity, alzhimers and even depression. However, eliminating these disorders from the human genome is not a reality yet, especially when eliminating them before one is born.



He Jiankui, a scientist from China was the first to attempt gene therapy on babies even before they were born i.e, on embryos. He tried it on embryos from parents where one of them was HIV positive. The rationale for this process can be understod by imagining that your body has multiple doors and the virus has a key to just one. This door is the CCR5 protein. He Jiankui deleted the gene which codes the protein from these embryos, therefore replacing the door with a wall. The virus canot infect the babies now. However, the CCR5 protein has other functions in the body. These functions could now be hamplered in the babies. Apart from that, making edits in the human embryo is a very risky process. The tools might end up editing the wrong gene, which can prove to be very lethal. He Jiankui's venture was met with severe criticism. He was sentenced to jail for three years. He was also stripped of his rights to conduct research again. Two of the babies were reported to be born healthy; however, one was born without the edited sequence.

Are we ready for the repercussions?

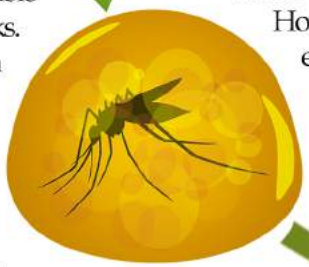
Science and technology could probably give us the perfect gene editor in a couple of decades. But the cost of such a technology cannot be estimated. Genes have been linked to a wide range of human characteristics including personality traits, physical build and so on. In the dystopian picture that *Gattaca* paints, the rich who are able to afford gene therapy make babies more likely to excel in society, thereby increasing the economic gap between the rich and the poor. Individuals with edited genomes are known as valids. The rest are known as invalids and are often poor. We see a dystopian society where the invalids are not allowed to become scientists or engineers. Recruitment for jobs are mere evaluations of the genome by sequencing DNA from a strand of hair. Thus, for gene editing, the chalenges posed by the human society is much lager than the technical challenges. We see the story of our protagonist who is an invalid trying to pose as a valid to follow his passion. In one hour and forty eight minutes, Andrew Niccol has given a scrupulous insight into a world where 'your DNA is you' along with a mind grappling storyline. A must watch to understand how science is much more than we thought it is.

JURASSIC PARK

Jurassic Park, directed by Steven Spielberg, is one of our all-time-favorite sci-fi adventures. However, it remains more of fiction than science Let us revisit how a dinosaur was built according to the movie. According to Mr. DNA from the movie, mosquitoes that fed off dinosaur blood were preserved in tree sap that fossilized to form amber. Next, these fossils were found, and dinosaur blood was extracted from them. Then, the scientists obtained fragmented dinosaur DNA from the blood, which was then patched with parts from the DNA of a frog. The complete genomic sequence was transferred to the nucleus of an egg. Lo and behold, you have a baby dino. Except you don't have the enormous amount of luck and the gigantic leap of science that enabled it.

Blood From Mosquitoes

DNA from blood obtained from mosquitoes can be isolated for up to two days after feeding for forensic analysis. However, blood decays so fast that when kept in a jar in your room, it would be unrecognizable after a couple of weeks. Fossilization is known to degrade most complex organic molecules due to the high temperature and pressure conditions. Hence, the preservation of blood inside mosquitoes seemed impossible until 2013. Dale Greenwalt, a biochemist, discovered a 46 million old mosquito to have blood proteins inside it. Found near Montana in the U.S, the mosquito was preserved in sand, and Greenwalt describes it as a rare combination of conditions such as lack of oxygen and fine layer sedimentation that enabled such a high degree of preservation. A heme group (a blood pigment) was detected under a secondary ion mass spectrometer. However, obtaining DNA would be technically impossible as the half-life of DNA is reported to be near 521 years. Patching up a DNA strand degraded into tiny bits and fragments of a few 100 base pairs to build an organism's entire genome is a herculean task. Imagine shredding a plain A4 sheet into a million pieces and then putting it back together in the exact positions as it was earlier.



But could we have Dino DNA?

Though Paleontologists discover bones and teeth of Dinosaurs all the time, it wasn't until 2005 that Mary Schweitzer could extract soft tissues from the remains of a T-Rex. She and her team were able to extract blood vessels preserved between the bones. In 2020, Jack Horner, a renowned paleontologist discovered what might have been cells within calcified cartilage in the remains of a herbivorous duck-billed dinosaur *Hypacrosaurus stebingeri*. On closer observation, dark condensed symmetrical structures resembling chromosomes were discovered. The scientists believe that the chromosome structure is not from the metaphase of an actively dividing cell but from the initial stages of cell death called chondroptosis, where similar structures are found. However, the scientists have not tried to extract the DNA as it is likely to be highly fragmented and we currently do not have the technology to extract it without causing considerable damage.

Death to Life- is the blueprint enough?

The nearest we have been to bring an extinct organism back into life was the attempted revival of the wild goat *Bacardo*, in 2003. The goat went extinct in 2000, however, its cells were preserved. Reproductive physiologists led by José Folch replaced the nuclei of the eggs of related goat species with the nucleus of *Bacardo* and implanted them into the uterus of the goats. All of them miscarried except one which was able to carry to full term. The newborn bucardo died 10 minutes after its birth because of a deformed lung.

The Lazarus Project in 2013 attempted to bring *Rheobatrachus silus*(a gastric-brooding which became extinct in 1983) back to life. They carried out somatic cell nuclear transfer (SCNT), which involves replacing a distantly related species' nucleus with the extinct frogs's nucleus preserved from the 1970s. They were able to produce a mass of cells from a single cell that contained the genetic material of the extinct frog. In theory, it works perfectly we would have had the extinct frog jumping around now yet here we are celebrating over a mass of cells.

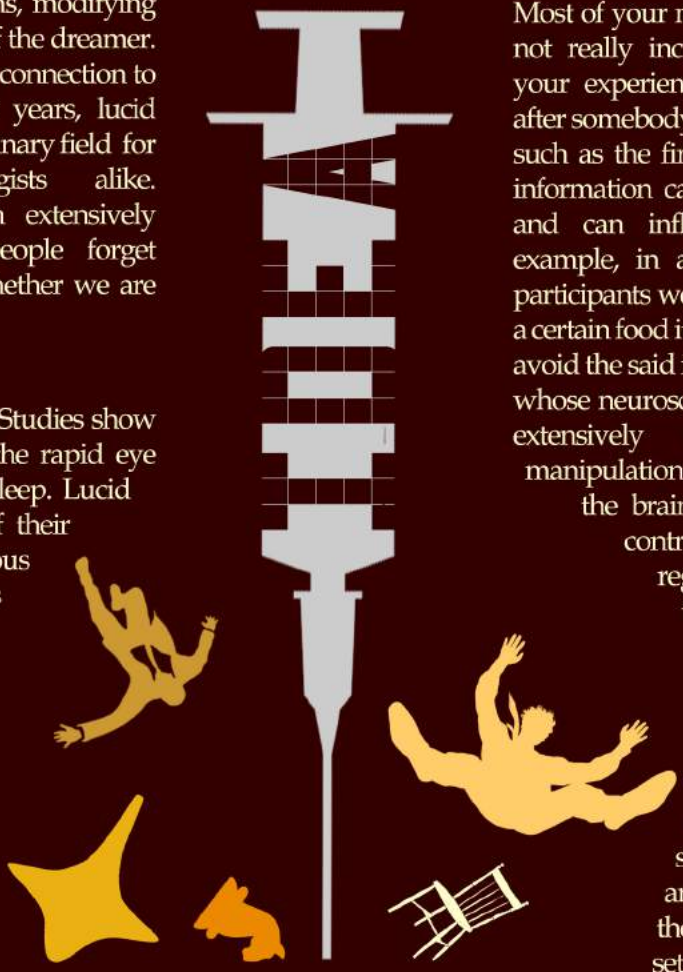
A building cannot be built from a blueprint alone. You will need architects, engineers, coordinators, masons, etc., along with the raw materials optimal for that building (you can't build a glass house with concrete). Similarly, though the genetic code is a blueprint, the genes cannot control the machinery of the egg unless the correct physiological and chemical conditions are met. These conditions are unique for each organism. Which is why no mater how hoard some of us wish, we canot be surogates for pupies. But let's say we manage to achieve the right conditions, by micro-controlling the envirnment of the womb. We might spend millions of dollars to bring an organism back into life just to watch it struggle to survive and probably go extinct again. The reason for them going extinct was probably the unfavourable enviornment or disturbances in their eco-system. These problems are not solved by genetic engineering.

INCEPTION

Written and directed by Christopher Nolan, this movie is about hijacking into dreams, modifying them and influencing the thoughts of the dreamer. It might seem very fictitious with no connection to science at all. However, in recent years, lucid dreaming has become an interdisciplinary field for neurobiologists and psychologists alike. Manipulating memories has been extensively researched, especially to help people forget traumatic events. Let us explore whether we are capable of inception yet.

Understanding Dreaming

Dreaming is a part of healthy sleep. Studies show that dreams often happen during the rapid eye movement (REM) segment of the sleep. Lucid dreaming is when one is aware of their dreams and can make conscious decisions in them. Lucid dreamers experience conscious awareness while still showing signs of the REM sleep cycle. In the 20th and 21st century it has been used as a tool to explore creative freedom and self-introspection. You even tend to remember these lucid dreams more often than non-lucid dreams.

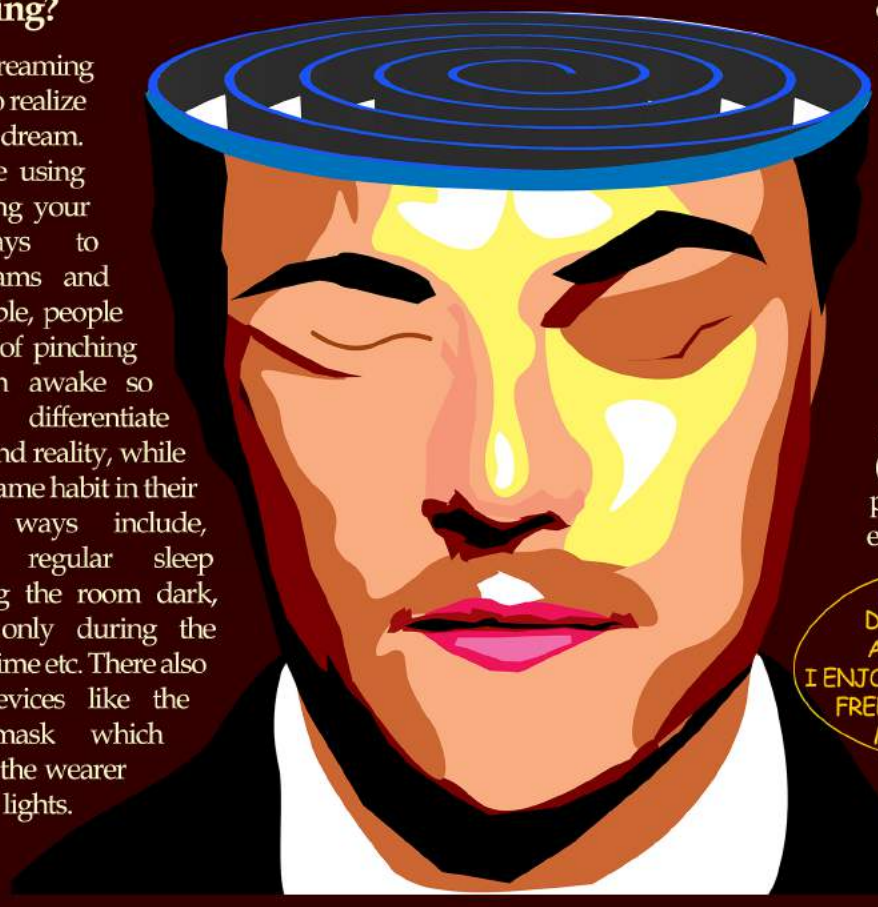


How to experience Lucid Dreaming?

The key to lucid dreaming lies in the ability to realize that one is in a dream. This can be done using cognitively training your mind in ways to differentiate dreams and reality. For example, people develop a habit of pinching themselves when awake so that they can differentiate between dream and reality, while they express the same habit in their dream. Other ways include, maintaining a regular sleep schedule, keeping the room dark, using the bed only during the designated sleep time etc. There also exists certain devices like the *Remee* sleep mask which communicates to the wearer by flashing 6 LED lights.

Science of brain manipulation

Most of your memories from childhood are not really incidents you remember from your experience rather what you believe after somebody narrated the incident to you, such as the first day at school. Misleading information can be planted into the brain and can influence future actions. For example, in a study in 2008, when the participants were told that they fell ill eating a certain food item in the past, they tended to avoid the said item in the present. Hypnosis, whose neuroscience has been studied more extensively than cognitive memory manipulation shows that certain areas of the brain including those for motor control show varied activity from regular brain activity explaining the involuntary experiences. Auditory and optical stimuli along with context have been known to trigger this switch in the state of the brain; however, the exact mechanisms and reasons are still unknown. The dream architect in the movie provides these audio and visual signals set in the dream to make the dreamer more susceptible to the manipulation. Scientists have also used optogenetics to implant false memories in mice. Optogenetics is genetic modification neurons to be sensitive to light. These neurons were inserted into the hippocampus, a part of the brain which is responsible for learning and memory. Upon manipulation, the mice recalled unpleasant experiences (shock) at places where they previously had no such experience.



Can you get stuck in a dream?

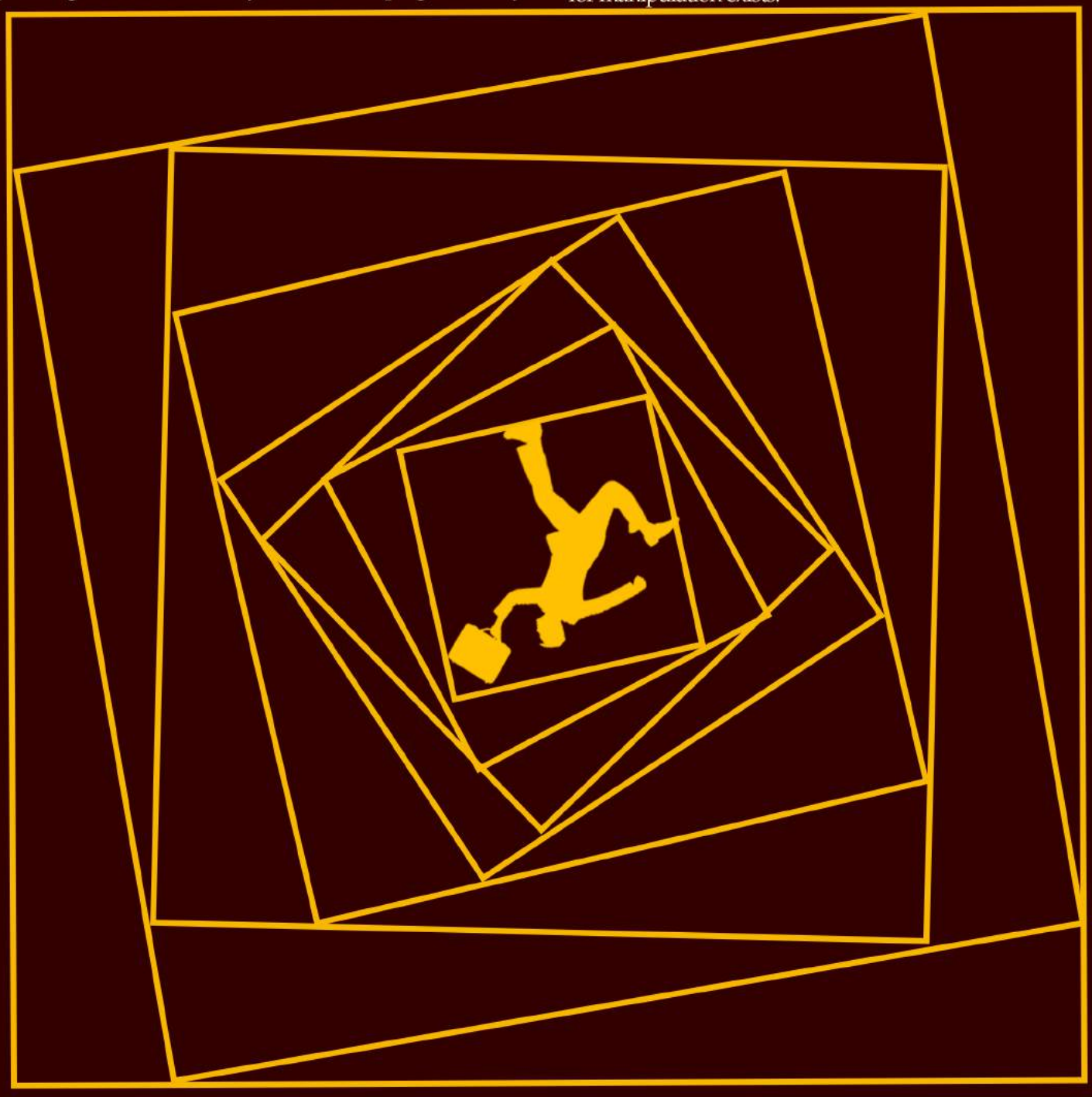
According to the movie, time passes slower in dreams and when you have a dream within a dream, time passes even slower in the next level and so on, until it is so slow, that you finish living your entire life in it before your alarm rings in the real world, resulting in your soul being lost. However, in reality, this is not possible as time does not go slower in dreams. This was verified with lucid dreamers keeping a count in their dreams which matched with the real time counts. We feel the dreams are shorter because we dream only during the REM cycle. Dreams can only last as long as your REM cycle lasts which is around 90 minutes under normal conditions.

False Awakening

When lucid dreaming, all your decisions and actions are withing the dream, sometimes even the decision to wake up. For example, that one time when you dreamt that you woke up and gave a test while you were sleeping in reality. This might result in you feeling trapped. Lucid dreamers have to be aware of the surroundings that they fall asleep in so that they can picture it during the dream to facilitate waking up. This is similar to the concept in the movie where a dreamer must simultaneously falls in the dream and in reality to wake up.

Reality of Inception

Techniques for manipulation of memory exist currently, however none exist with the sophisticated mechanism as demonstrated in the movie. Designing the dreamscapes, with a dream architect does not go with the spontaneous creativity in natural dreams. Presently, we only know how to influence a person and their subconscious by hypnosis. Entering another person's dream and making conscious descions within their dream is fiction. Dreaming is known to be an activity that improves cognitive abilities and refreshes the brain than a tool for manipulation as shown in the movie. You may sleep soundly at night knowing that no technology for manipulation exists.



X-MEN WOLVERINE

The long claws and rapid healing powers of Wolverine is attributed to his X-gene mutation. Logan a.k.a Wolverine was born with such a mutation which seems to express itself when he is anxious or stressed. His mutations enable him to walk away from bullets fired into him unscathed. Sounds like magic but let us give science a chance to explain.

Rapid Healing:

Wound healing is a very complicated process whose cellular mechanisms are not completely understood yet. An analogy would be to imagine your body to be a huge bank. And one of the walls of this bank is blown off. The response to this would involve first blocking any internal processes such as transport of any cash or people through this area of the bank and then temporarily sealing off the wall to prevent unnecessary people entering from outside. In our body, this would translate to constricting blood vessels to restrict the flow of blood into this area, while forming a clot that plugs the wound. The next step would be to deploy security and the fire force workers to remove any unwanted people who might have wandered in or people injured in the blast.

People would also be deployed to remove the useless debris from the blast. This would be the inflammation stage of wound healing where your immune cells enter and clean the wound of foreign bodies and dead cells. After that an architect or a civil engineer would be called to plan the repair, they make blueprint of a plan and leave markings as to where and how exactly the wall must be repaired. This is like growth factors being released the site of wound which guide migration and division of cells in the next phase. The workers now come in with raw materials like bricks, cement, plaster etc. and start rebuilding the wall. The bricks can be thought of to be like cells and the cement paste which holds it together as the extra cellular matrix (ECM). The cells and ECM guide each other through chemical signaling as to how the tissue must be reformed. Simultaneously the temporary adjustments from the building are removed, the electrical wirings etc. are restored, and the wall is let to set and gain strength before making this section of the bank completely functional again. In your body, this mechanism would take place in the maturation stage.

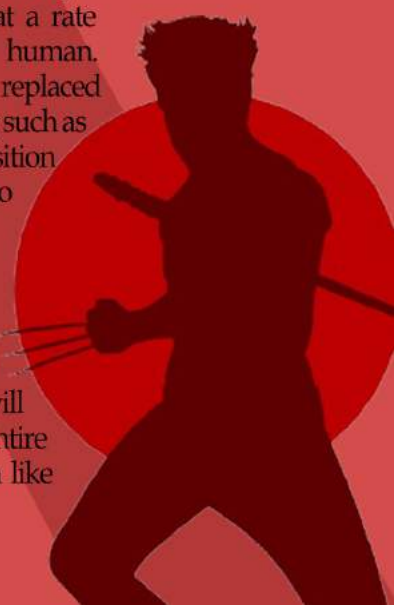
All these stages are coordinated by chemical signaling pathways making it very complex. For rapid healing powers like that of wolverine, all these stages need to be sped up significantly while remaining coordinated. However, the most significant for wolverine would be cell proliferation i.e., rapid cell division. Normally, our body produces 30,000 to 40,000 cells per minute to replace the old and work out cells. However, to heal a minor wound, a significantly larger number of cells need to be produced.

Rapid cell division

Cell division is a result of multiple coordinated bio-chemical pathway which are controlled by proteins called cyclins and cyclin dependent kinases. Rapid cell proliferation has been observed and its chemical induction has also been studied extensively. Unfortunately for us, this is associated with cancer and tumors where the chemical inducers are the numerous carcinogens that we know of. P53 is a gene whose mutation is observed in roughly 50% of the cancers. The p53 gene in our bodies acts as a regulator, and controls cell division. The gene senses the stresses or damages within the cells and causes arrest of growth, repair of the damage or if the damage is beyond repair, it causes cell death or apoptosis. These involve numerous mechanisms such as regulation of nutrients, proteins etc. Deletion of this gene results in rapid proliferation, where the cells now have access to nutrients to rapidly divide. The mechanism of DNA repair is suspended, the cell is now not sensitive to intercellular signaling and so on. The compromise of the repair mechanism lead to further mutations in the cells of the tissue, making them nonfunctional while taking up all the nutrients from the healthy cells and slowly killing you. The mutation in wolverine ensures that all cells have the same high uptake of nutrients for cell division and a DNA repair mechanism that is much faster than the ones in our cells. An ideal scenario where set of mutations that allows rapid cell division while allowing the repair, the sensitivity to other cells, and faster chemical reactions, might allow you to become like wolverine. However, with our current understanding of cellular mechanisms change in even one of the factors will most likely disrupt this balance and cause the body to malfunction. The bio-chemical balance is delicate and cannot be disrupted.

Anti-aging

While numerous epigenetic pathways have been studied for anti-aging, incase of wolverine, more than epigenetics, it is likely to be his rapid cell division that keeps him young. The cells in his body are constantly being replaced at a rate much faster than a normal human. Hence, when old cells are replaced continuously, the effects of aging such as wear and tear of old cells, deposition of the ECM in the old cells are no longer observed. Thus, wolverine's body shows no sign of aging owing to his cells always being young and new. Thus one muation won't make you wolverine. You will need to change your entire biochemical balance to function like the wolverine's cells.



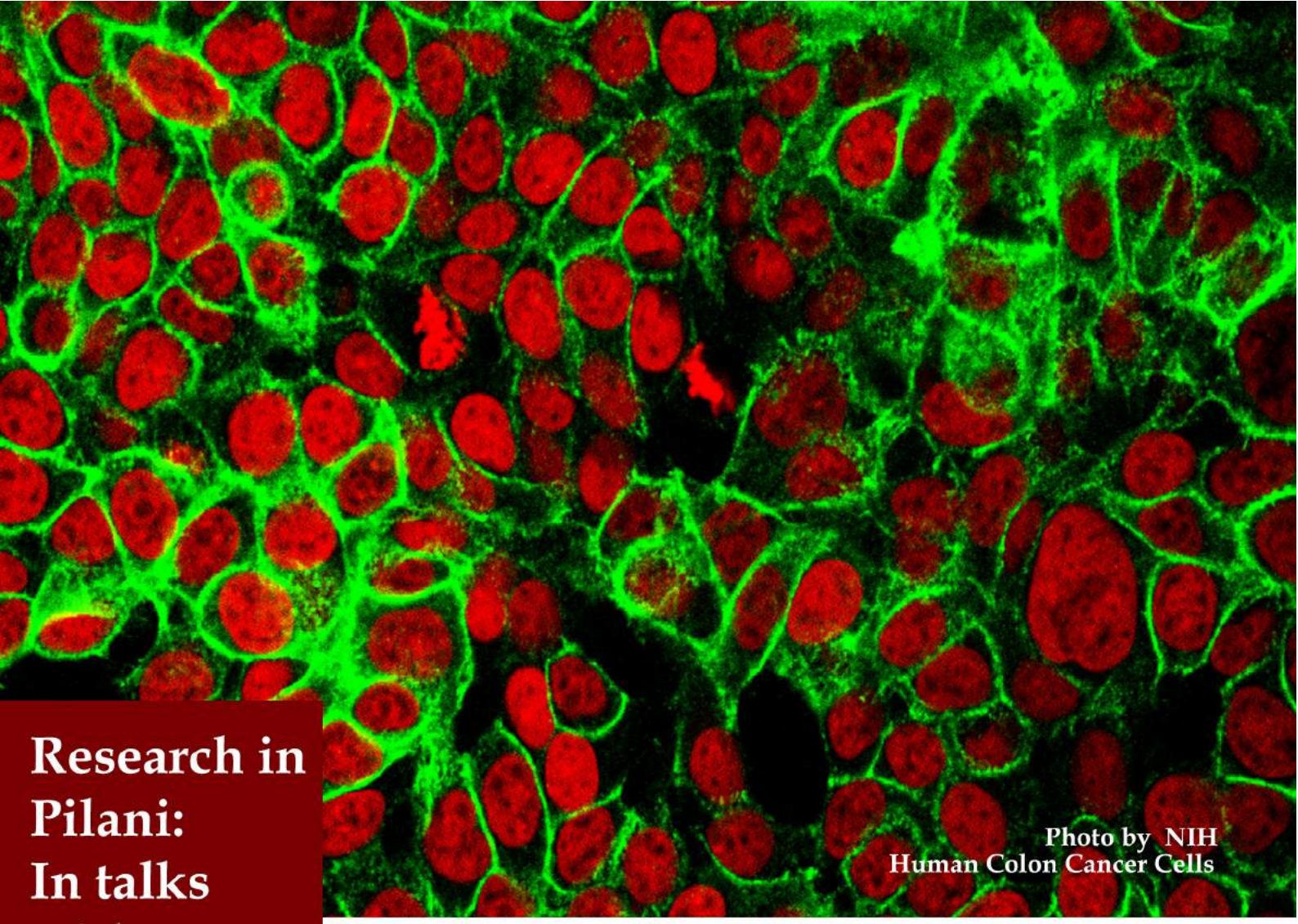


Photo by NIH
Human Colon Cancer Cells

Research in Pilani: In talks with Dr. Rajdeep Chowdhury

Cisplatin is a platinum based drug and is one of the parent drugs for multiple tumours as well. Generally in case of tumours one single drug is not given rather a combination that targets different cell responses for example, a drug A may show significant effects but at the same time it switches on certain proteins that throw it out of the cell. Hence you need another drug B and likewise cisplatin might be given with different drugs for the maximum efficiency. Since our research is not a clinical one and is being done on cultured cells that were extracted from a patient suffering the disease, we subject it to the kind of drugs that would generally be given to the patient and one of them was cisplatin.

When a patient is diagnosed with cancer, chemotherapy is recommended and in some cases the patient reacts very proactively in the initial stages and a relapse is observed; that is, the same dose of drug does not seem to work rather a higher dose is required and this harms the other living cells as well. What we learn from this is that these cells go into a dormant or sleeping state and stay there as long as there is acute drug pressure. After a few months they come back and repopulate the tumour! It is quite a smart and evolutionary way that these cells undergo. So our research group tries to figure out what are the molecular reasons behind the tolerance towards drug pressure.

Osteosarcoma or bone cancer is mostly found in children and even in adults and is often treated with toxic doses of Cisplatin which tells us that these cells somehow are able to withstand the lower doses and thus give a promising outcome. Hindrances to its therapy,is in the ability of these cells to survive higher doses by modifying itself into a dormant state. So in short, no matter how much you increase the dose the cells may evade it.

We tried to simulate the clinical process. Once the drug had been given, the majority of the cells would die however the ones that remain are the tolerant ones and are labeled "Persisters" (OS-P). Now these persisters go into a hibernation phase and after a few months come back to repopulate the tumour they would be the "Extended Persisters"(OS-EP). Had it been a clinical trial, the patient would have undergone another round of chemotherapy a bit higher dose this time and the cycle of dormancy and proliferation continues. After repeated such cycles the cells that emerge turn out to be resistant to that drug and are termed the "Resistant" (OS-R). And ofcourse, the fourth one is the control, the non drugged Osteosarcoma cells (OS).

The RNA of the different test cases- OS-P, OS-EP, OS-R and OS -were compared. This entire process is called "transcriptomic analysis". This RNA is outsourced to a e.company that sequences it and gives raw data which is analysed by us and then we compare this data with the already available data on the entire human genome and we get the tags to which section it represents. Then we do Dsec or differential expression analysis and this helps us conclude what kind of proteins are in higher concentration or are upregulated and what are downregulated between say the control test case and the persister test case. And then there are softwares that tell us which biochemical pathways these proteins belong to and other information

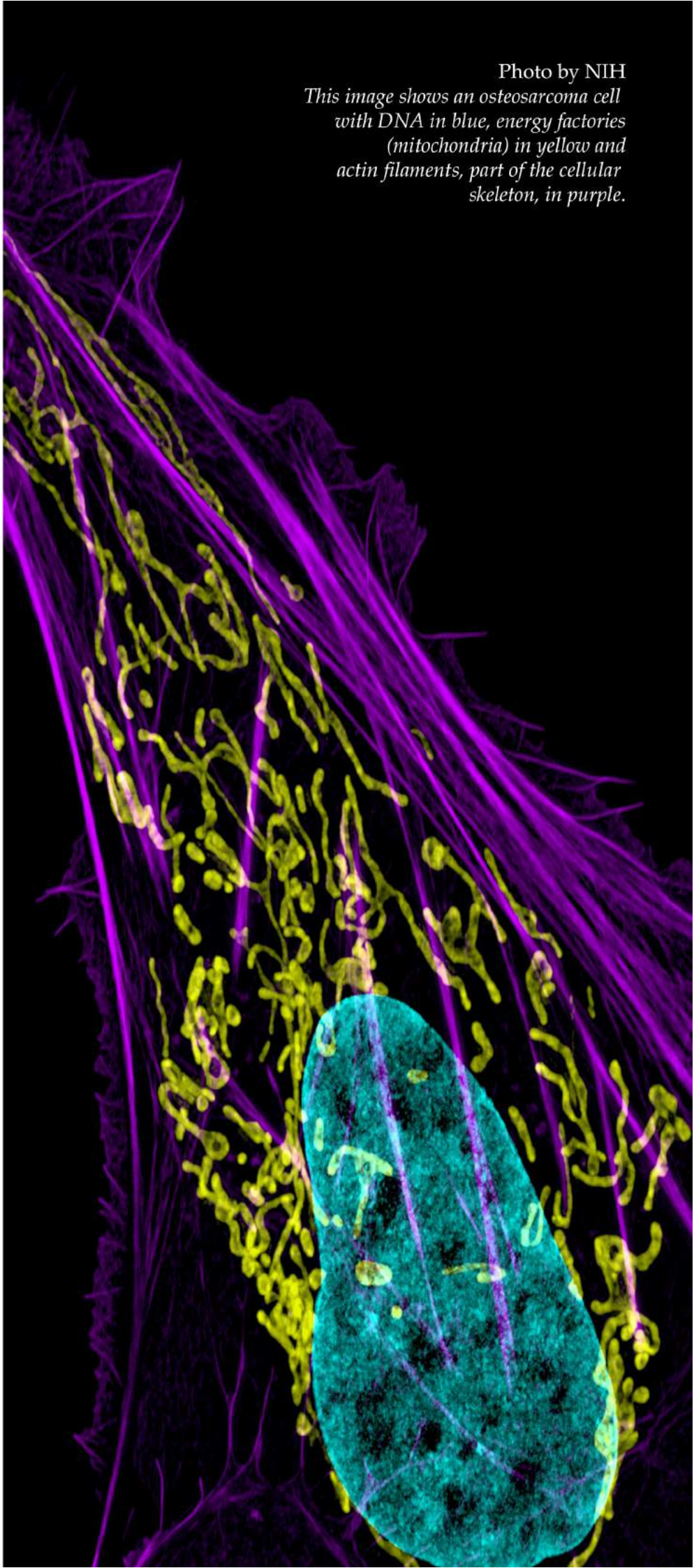
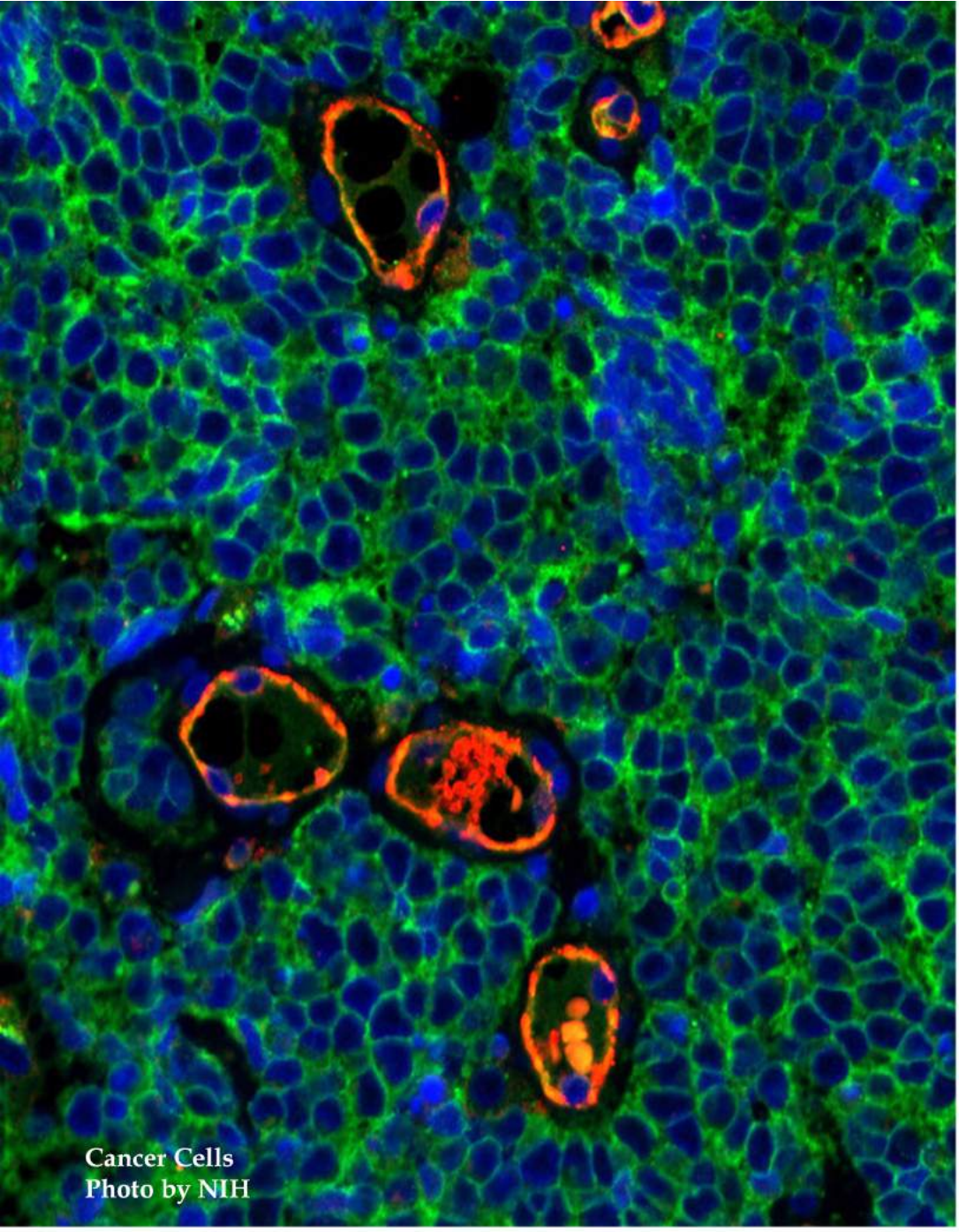


Photo by NIH

This image shows an osteosarcoma cell with DNA in blue, energy factories (mitochondria) in yellow and actin filaments, part of the cellular skeleton, in purple.



Cancer Cells
Photo by NIH

It has been observed that many times if a patient is given a particular drug and is kept without a drug that is, given a drug vacation, for example a tumor patient visits a clinic, we diagnose the cancer and treat it with a particular drug. We get the resistant cells and say these resistant cells are the ones adapted to the drug pressure. During the drug pressure they may show some adaptation, say, epigenetics, to resist the drug pressure. When we don't treat it with the drug for sometime and then introduce the same drug later, we notice that the cells lose their adaptability and succumb to the same drug. This signifies this is not a mutation or permanent feature of cells.These cells are dynamic to the situation.

Written by Aryan Charak

Some of the features we have observed that cells can tolerate some amount of acute drug pressure, they go into a non-dividing phase when they are tolerating it.We figured certain pathways which might be instrumental.
We have a big set of data which we need to validate experimentally as they are markers and there are aspect we are looking into, one of it is epigenetics. We understand that this is not a phenomenon which is like heritable rather it is an acquired change in the genome or as we call it epigenetics. Hence, targeting the epigenetic modifiers which can regulate the genetic material might be a good approach along with primary therapy i.e. cisplatin.
So we deliver cisplatin along with a drug which won't allow the cell to go into the mode to change its chromatin and survive that tolerant state. We are at the initial phase where we have done those transcriptome analysis and now we are looking into epigenetic targets . We would like to extend our research beyond osteosarcoma. What we understand from existing literature is that similar research is also available all over the web, it's a competitive field. Marry classen groups are researching it ,working in similar fields and trying to identify the target which can be the most sensitive to these tumors. Finally I would like to say that there are reports which say that after a drug pressure a single cell may behave differently compared to its peer now people are doing these experiments from a single cell genomics aspect.

NEW SPECIES ALERT

Credit: Todd Pusser

Eurycea arenicola

Carolina sandhills salamander Can be found in springs and backwater rivers of Northern Carolina. With crimson red scales, it is easy to spot. Though it had been spotted 50 years ago, it was believed to be an endomorph of similar salamanders found in the area.
However, after mitochondrial DNA and nuclear DNA analysis showed that this little guy is not related to any of the species in the same area, hence being declared as a new species in 2020.

Credit: Wessel Swanepoel

Tiganophyton karasense

This plant is an evergreen dwarf shrub, which grows in the arid regions of southern Namibia. It resembles some of the cacti species and has scaly and fleshy leaves that help it to survive the harsh conditions of the desert. Fewer than 1000 individual plants of this species have been found so far in the same area, hence being declared as a new species in 2020.

Oreobates zongoensis

The devil eyed frog, a species spotted only once twenty years ago, was found in incredible abundance by a scientific expedition in the cloud forests of the Bolivian Andes. Discovering the black frog with red eyes had been a pleasant surprise, for it was believed to have been wiped out when a hydroelectric dam was built in its rumoured place of residence.

Credits: Steffen Reichle

Credit: The Smithsonian Magazine

Loureedia phoenixi

The Loureedia phoenixi, belongs to the Loureedia family named after punk rock artist Lou Reed. This new addition to the family however stands out because of the bright white and red markings on its back which resembles the Joker's grin from the 2019 movie, which is why it is named in honour of the Joker's actor Joaquin Phoenix. Spiders belonging to this family show some unique traits like building communal nests and caring for the young.

Credits: Daishi Yamazaki

Tegula Kusairo

A species of edible snails called Tegula Kusairo was discovered in Japan. These marine snails have shells that are brownish-green with a white or yellow underside. They mainly inhabit the shores of Japan and South Korea.

T*rimeresurus Salazar*

This is a venomous pit viper, is named after a character from the famed fantasy fiction, Harry Potter. Its diet includes rodents, lizards and other small mammals. This snake is nocturnal and is found to be coiled around shrubs at night. It is characterised by a beautiful rusty-red stripe along the face that continues all the way down its side.

Credits: *The Smithsonian Magazine*

Trachypithecus popa

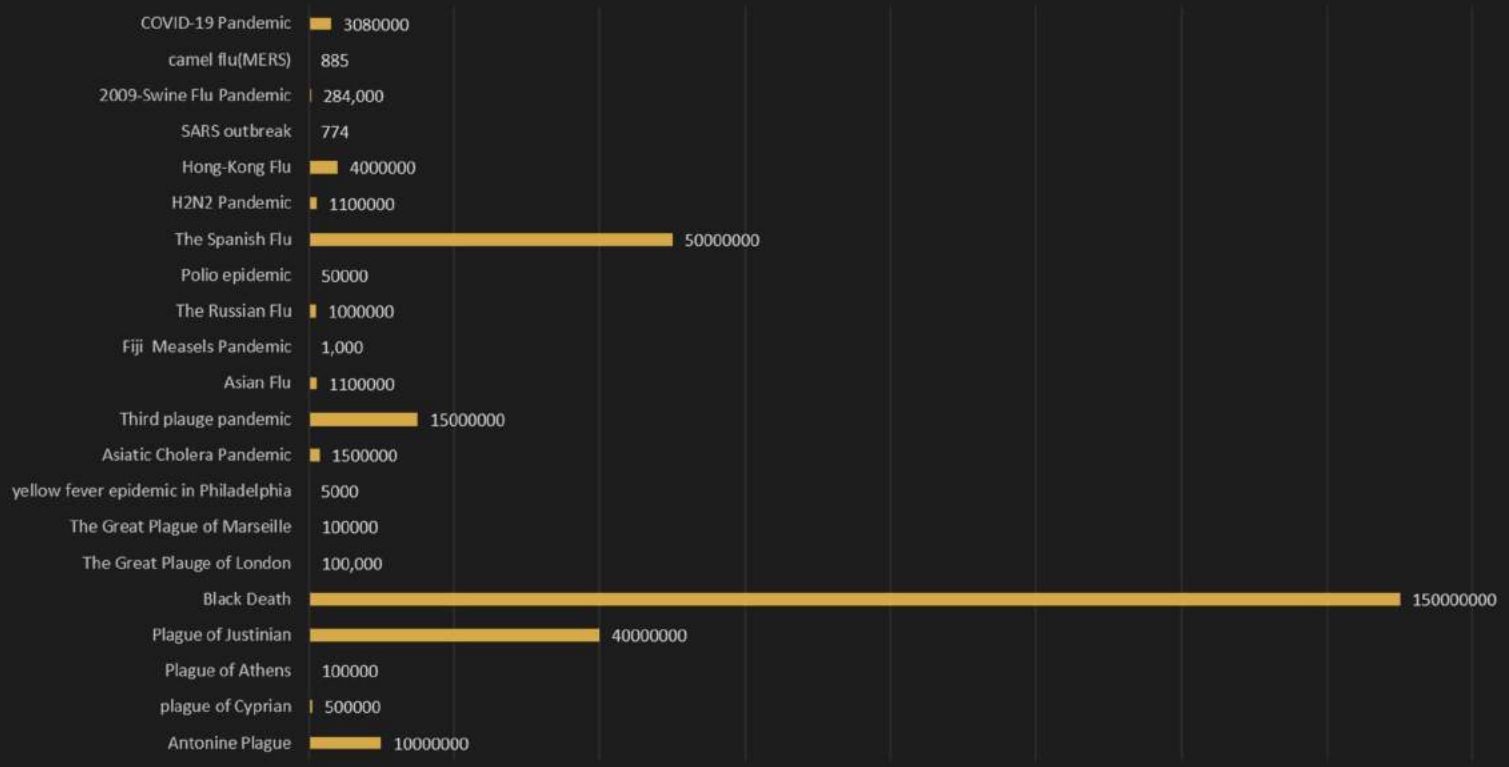
The Popa Langur has fluffy fur, white eye-rings, little black "gloves," and a crest of fur on its head. It has been alive on earth for at least a million years but sadly was found to be facing extinction soon after its discovery.There are fewer than 250 of them left and are mainly leaf-eaters known for the distinctive eyepatches and greyish fur.

Credits: The SmithsonianMagazine

PANDEMIC INFOGRAPHIC

Diseases have been prevalent in the human population since the dawn of time. The emergence of a pathogen and its eventual eradication is something that has been observed over and over again. We bring to you a crisp history of plagues and what we can learn from them.

Death Toll of Various disease outbreaks



Data on pathogens

It was often noticed that the pathogens were either carried around trade routes or spread by way. The spread of diseases became more rapid as our transport facilities got better.

Name	Cause	Location
Antonine Plague	smallpox or measles	Rome
Plague of Cyprian	smallpox, pandemic influenza, and viral hemorrhagic fever	Europe
Plague of Athens	30 different pathogens identified	Rome
Plague of Justinian	Bacterium *Yersinia pestis*	Mediterranean Basin, Europe, Near East
Black Death	Bacterium *Yersinia pestis*	Afro-Eurasia
The Great Plauge of London	Bacterium *Yersinia pestis*	London
The Great Plague of Marseille	Bacterium *Yersinia pestis*	Western Europe
yellow fever epidemic in Philadelphia	Yellow-fever-virus	America
Asiatic Cholera Pandemic	*Vibrio cholerae* bacteria	India, Myanmar, Sri-Lanka
Third plauge pandemic	Bacterium *Yersinia pestis*	China, Hong-Kong, Japan
Asian Flu	influenza A (H2N2)	China
Fiji Measels Pandemic	Measels virus	Fiji
The Russian Flu	influenza A virus subtype H2N2.	Russia, Eurasia
Polio epidemic	enteroviruses	US/Cannada
The Spanish Flu	A/H1N1 influenza virus	Europe, US, Asia
H2N2 Pandemic	influenza A (H2N2) virus	East Asia
Hong-Kong Flu	influenza A (H3N2) virus	Asia
The Aids Pandemic	HIV	Worldwide
SARS outbreak	SARS-CoV-1	China
2009-Swine Flu Pandemic	influenza A (H3N2) virus	World-wide
camel flu(MERS)	MERS-CoV	Arabian Peninsula
Epidemic of Zika fever	Zika virus	Brazil, North-America, South- America
COVID-19 Pandemic	SARS-CoV-2	World-wide

BIOMIMICRY

Earth, which is home to a large number of organisms, has not just promoted a competitive environment for the 'survival of fittest' but has also seen one organism taking inspiration from another to improve survivability. Building on this is the budding field "Biomimicry" which takes inspiration from nature. Biomimicry not only aids in creating new products and processes in a sustainable manner but also helps overcome design challenges.

Try and match the invention to the biological inspiration before we start off!

Surgical Superglue

Dew Collector

Super Dry Surfaces

Bullet Train

Wall Climbing Pads

Nozzles of inkjet printers

Camouflage suits

Lotus

Slugs

Spiders

Human Eye

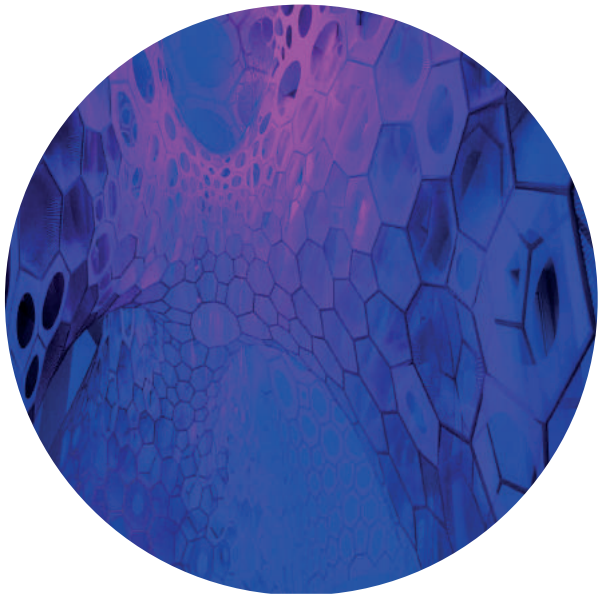
Bromeliad plant + Spider

Gecko

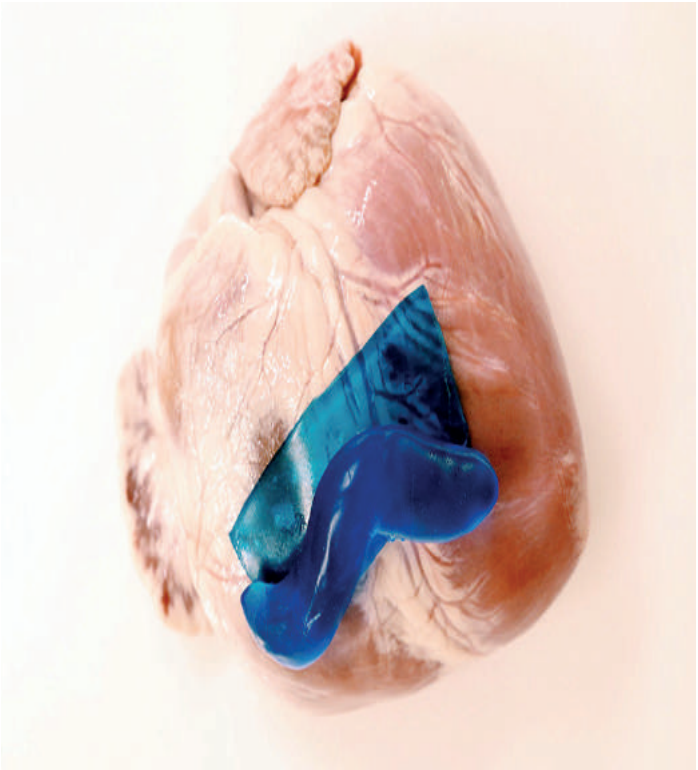
Octopus

Kingfisher

Fixing 'broken' Hearts



One classic application is the surgical superglue mimicking slug slime. Patching a hole in the heart or lung is an onerous task as they are wet organs and are constantly in mild motion. Conventional surgical adhesives are not sticky or flexible enough to work on such wet tissues. For a long time, researchers like Jianyu Li have been looking for a solution.



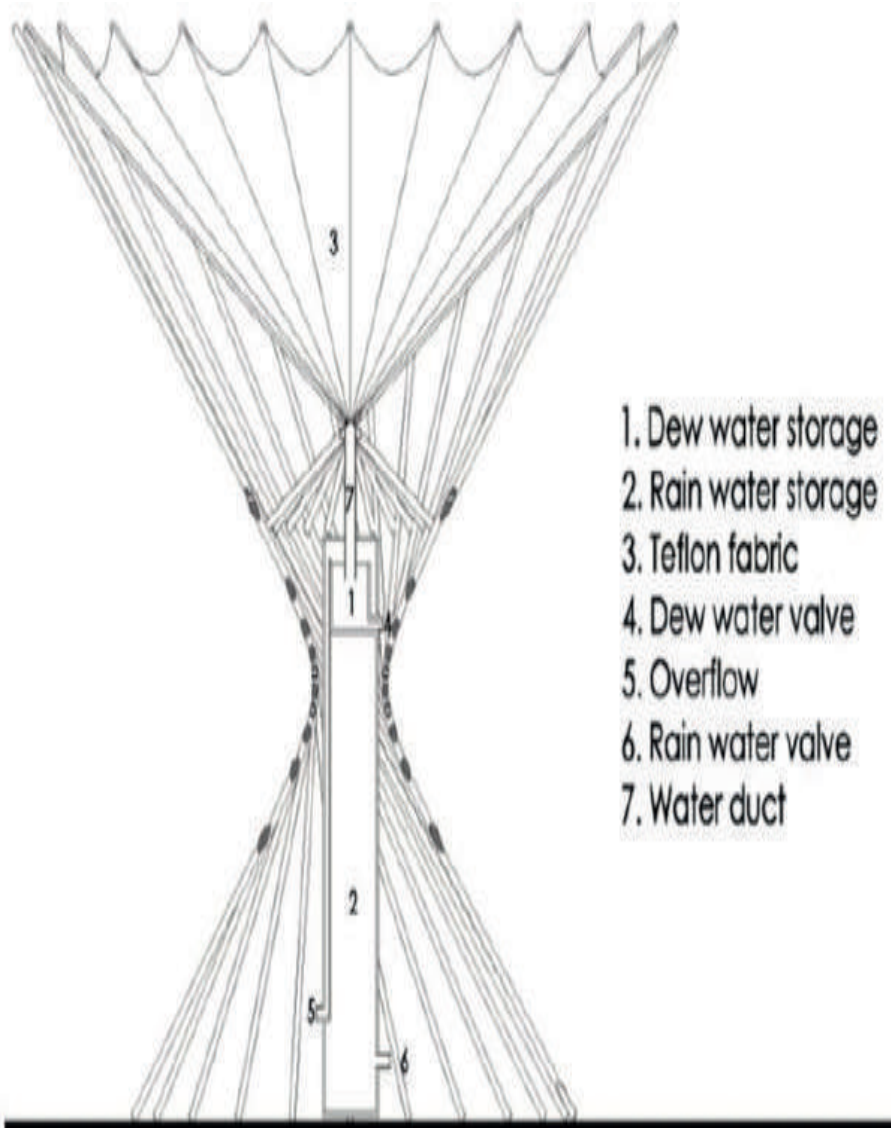
Inspiration struck when they analysed the mucus produced by slugs. This mucus is produced as a defensive response and allows the slug to glue itself to wet surfaces. While usually there is a trade-off between flexibility and strength, this defensive mucous is not only sticky but also is highly stretchable and strong. A research group from Harvard University took inspiration and made a surgical superglue and the formulation contained two layers where one layer is made of polymers bonded by strong bonds and the other layer is a hydrogel.

Combination of these two layers conferred strong and satisfactory adherence to tissues without triggering any immune reactions. Further research focus is on creating substances that would eventually disintegrate in the body once the organ has healed.

Water, water, Anywhere

Another great example is the dew collector that has been created keeping in mind the bromeliad plant and spider webs. Bromeliads belong to the same family as the pineapples. They have small hydrophobic cellular structures called trichomes on the epidermal cells of their leaves that allow them to absorb water and minerals from the leaf surface. As one goes closer to the epidermis, these cellular structures converge to form a collection tank which helps to trap water effectively until it is absorbed. Spider silk has also long fascinated scientists with its high tensile strength and adhesive properties to be mimicked in bulletproof vests and synthetic adhesives.

Spider webs typically consist of two different types of threads namely, the radial threads that radiate out from the centre of the web and the spiral threads which connect the radial threads. Previous research has shown that the radial threads are significantly stronger than spiral threads as they are thicker and have a different chemical composition. Physicists, Yuko Aoyananagi and Ko Okumura, who investigated the structural properties of spider webs discovered that, for a typical web, spiders could change the number of radial or spiral threads without reducing the overall strength of the web. Most elastic materials when damaged, experience a redistribution of forces, and a lot of stress is concentrated in the damaged area. However, they found that the overall strength of the web and the distribution of forces in it remained unchanged even in case of damage.



Inspired by the above stated phenomena, a team of scientists from Mexico adopted this approach to handle the problem of water shortage in their hot and humid hometown of Yucatan. They created a model for a dew and rainwater collector which consisted of 3 parts: a bamboo frame, a water collector and a water tank. The contraption, called Chaac-ha, is able to collect at least 2.5 litres of water per night and up to 50 litres of water during rains. The water tank was designed similar to the trichomes in bromeliad plants. The water collector was made out of Teflon which is hydrophobic, bacteria-resistant and flexible. The supporting structure for the collector was designed based on the radial distribution of forces on the spider web. During the night, dew forms on the Teflon fabric and its inclination allows the water to fall into the tank. The same applies for rainwater.

Super-dry Surfaces

The concept of "super-hydrophobicity" - the tendency of a surface to repel water drops - has inspired the scientific community in many ways. A real-life example of super-hydrophobicity is the property exhibited by lotus leaves towards water. Surface studies reveal that the lotus leaf contains tiny spike structures along with a waxy coat complementing a super-hydrophobic nature which rolls off water and dirt. Scientists have tried to mimic such surfaces for various applications like super-dry surfaces, antifogging mirrors and displays, self-cleaning windows and panels etc.

One of the leading applications is in the biomedical arena, where they can be exploited as substrates to control protein adsorption, cellular interaction and bacterial growth, as well as platforms for drug delivery devices and for diagnostic tools. Modifying the surface using nano textures has opened up avenues in creating desirable surfaces for tissue engineering. Protein adsorption onto a biomaterial surface can be tuned by fabricating the material with the appropriate surface roughness and curvature. Increasing the air between proteins – surface interface by incorporating a hierarchical structure has shown promising effects. Since there is prevention of protein binding, cells also do not adhere and proliferate on the surface. This property can be used to suppress bacterial adsorption and growth on medical implants thus preventing the formation of biofilms. Preferentially patterning the surfaces on a biochip can now allow select regions to remain superhydrophobic, hydrophobic and hydrophilic defining regions with different wettability to favour adhesion of molecules and movement of fluids. Superhydrophobic surfaces also provide useful platforms for supporting and handling microliter-scale droplets commonly used in many diagnostics, especially miniaturized point-of-care devices.

The Human Lizard?

Climbing over walls isn't just Spiderman's forte anymore. Inspired by the gecko, Stanford engineers came up with this ingenious design that essentially allows a human to climb up a glass wall. Studying the biomechanics of a gecko's toes, they created a device that spreads large loads evenly across every patch of the synthetic adhesive they designed, allowing it to support a person's weight.

Each of the handheld 'gecko pad' is covered with 24 adhesive tiles that have sawtooth-shaped polymer structures, each being about 100 micrometers long, which is approximately equal to the width of a human hair. Special springs on the pads apply an identical force to each adhesive tile when they're pulled on that causes these structures to flatten. So when there isn't any load only the tips touch the surface and so they aren't sticky but when weight is applied, the wedges turn over increasing the surface in contact creating an adhesion force. With this repeating cycle of load and no load, climbing is actually possible. Further, this invention could be used for creating robots that could lift heavy glass objects. The possibilities are endless.

The Silver Bullet

Another instance of biomimicry is the design of Japan's Shinkansen bullet train that many might know is based on the kingfisher. The Shinkansen was the fastest train in the world and could reach a speed of up to 200 miles an hour. However, it produced a lot of noise and would abruptly change air pressure when emerging out of tunnels, producing thunder-like sounds. The train's chief engineer, who was a birdwatcher, came up with an innovative design wherein the engine resembled the narrow profile of the kingfisher's beak. The resulting design made the train quieter. It also consumed 15% less electricity and moved 10% faster than before.

Crawling to safety

When it comes to places that are risky or tough for humans to get to, spider robots may provide a convenient solution. Spiders have a peculiar way of moving in which they keep four of their feet planted on the ground at all times and the other four turn and ready themselves to take the next step. This allows efficient movement even in places with a lot of obstacles. Based on this property, researchers at Germany's Frauenhofer Institute created the prototype for a spider-like robot that does the same and uses hydraulic bellows to move its legs. They have planned to use it as an exploratory tool after natural disasters or reactor accidents to assess the situation by tracking down hazards or leaking gases and broadcasting live images.
3D printers can be used for producing these robots which will have a modular design, thus allowing for quick assembly. They could even be specialized based on the purpose they will be used for by fitting them with appropriate sensors and cameras.

Unclogging our Images

Inkjet printers are able to print images on paper using dropper-like mechanisms by depositing microdroplets of ink, through a nozzle. A processing unit is responsible for the control of this deposition and that along with the superposition of the various color droplets gives us the desired image. Now, ink might dry up on this nozzle leading to clogging causing a malfunction.

Initially, this problem was solved by releasing a burst of ink so that the pressure would displace the dried-up ink but this was a wasteful and time-consuming approach.
Later on, it was noticed that the eyes also face this problem as they, like the nozzle, cannot be left to dry out but have to stay open at the same time.

Here, the problem is solved by having a thin film of oil which prevents the layer of tears from getting evaporated. Jae Wan Kwon, associate professor at the University of Missouri, used silicone oil to cover the opening of the nozzle when not in use. In the eyes though, this oil is applied by the eyelids but at the scale of the nozzle, mechanical shutters wouldn't open due to surface tension. So, he utilized an electric field to easily apply and remove the oil droplet thus creating the clog-free nozzle we use so often.

Octopuses- Too Tenta-cool!

The octopus, one of the most fascinating creatures to exist on this planet, is an invertebrate which has evolved a form of higher intelligence over time. This creature has one of the highest brain-to-body ratios for an invertebrate. Interestingly, two-thirds of its nervous system is in its body allowing its arms to perform independent actions from responding to pain to grabbing objects.

Perhaps, one of the most impressive feats of neural control is the octopus's ability to camouflage. They have sacs in their skin called chromatophores which are full of coloured pigments like black, brown, orange, red and yellow and their skin has projections called papillae whose size is neurally controlled by the octopus. Researchers compare the papillae to pixels on a screen as the superposition of many papillae of varying intensity generates texture, like pixels generate images. Their skin can thus form all types of textures ranging from small bumps to tall spikes allowing most octopuses to change the shape and colour of their skin to blend in with the external environment.

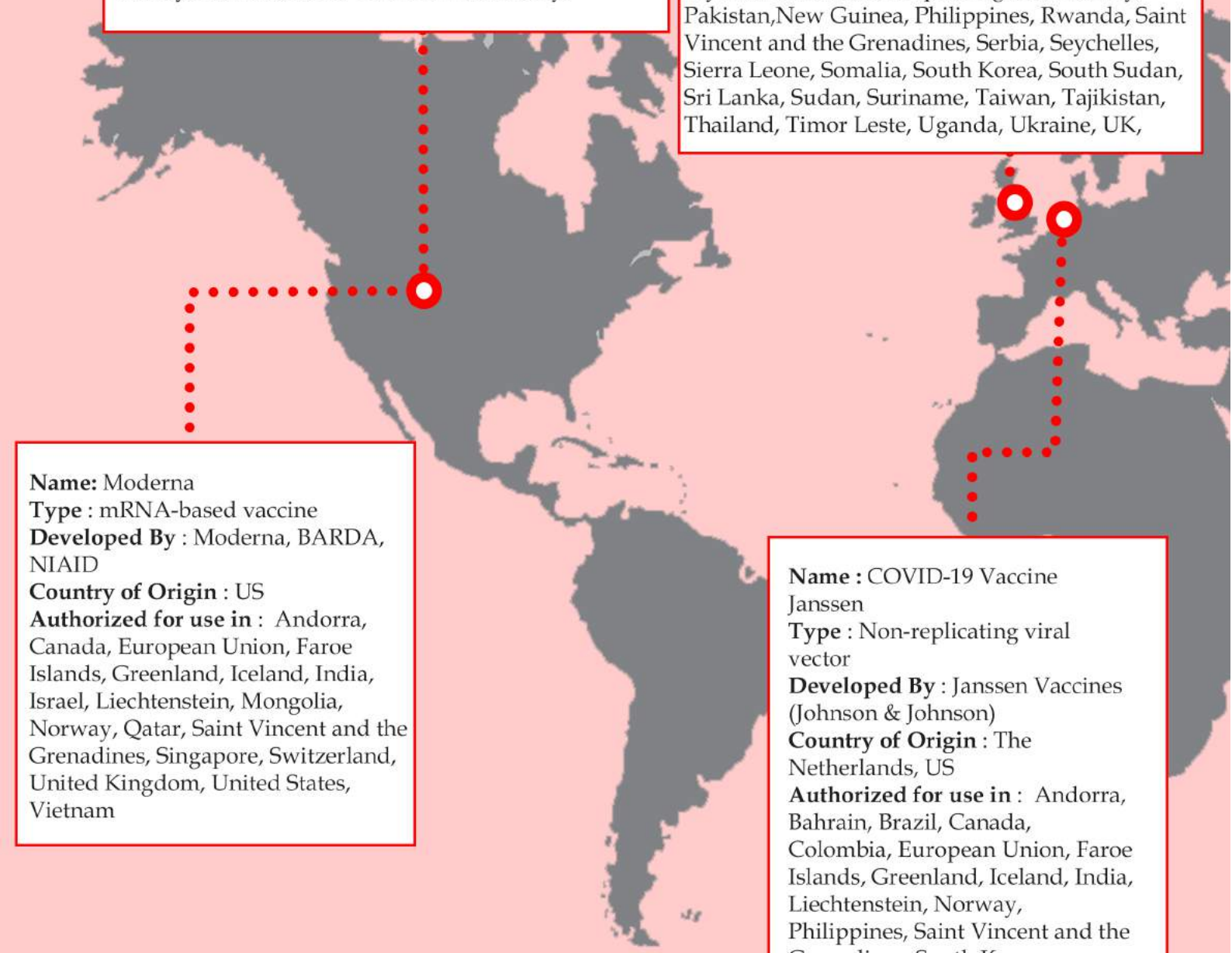
Taking inspiration from this, James Pikul and Rob Shepherd developed a skin-like material that can inflate and expand into different shapes. It was mainly developed for use in Soft Robotics, which, as it sounds like, involves the creation of useful robots that have high flexibility and adaptability while performing tasks, coupled with minimal capacity to harm human beings and other living creatures. These materials have also been used for camouflage suits and in many tech interfaces.

Looking Ahead

Biomimicry illustrates that the answers to many challenges lie around us and all that is required is keen observation, inspiration and vigour to put thoughts into action. As innovators, it is crucial that we take inspiration from our surroundings and come up with sustainable, functional and eco-friendly solutions. Thinking of nature as an inspiration to innovation is the key to how 'Biomimicry' has evolved as a field today.

Name : Comirnaty(Pfizer)
Type : mRNA-based vaccine
Developed By : Pfizer, BioNTech; Fosun Pharma
Country of Origin : Multi-national
Authorized for use in : Albania, Andorra, Argentina, Aruba, Australia, Bahrain, Bosnia and Herzegovina, Brazil, Brunei, Canada, Caribbean, Chile, Colombia, Costa Rica, Ecuador, European Union, Faroe Islands, Greenland, Hong Kong, Iceland, India, Iraq, Israel, Japan, Jordan, Kuwait, Lebanon, Liechtenstein, Macao, Malaysia, Maldives, Mexico, Monaco, Mongolia, New Zealand, North Macedonia, Norway, Oman, Panama, Peru, Philippines, Qatar, Rwanda, Saint Vincent and the Grenadines, Saudi Arabia, Serbia, Singapore, South Africa, South Korea, Suriname, Switzerland, Tunisia, Turkey, Ukraine, UAE, UK, US, Vatican City.

Name : Oxford, AstraZeneca(Covid Shield)
Type : adenoviral-based
Developed By : Oxford University, AstraZeneca
Country of Origin : UK
Authorized for use in : Afghanistan, Albania, Algeria, Andorra, Angola, Argentina, Australia, Bahamas, Bahrain, Bangladesh, Barbados, Bhutan, Botswana, Brazil, Brunei, Cabo Verde, Canada, Chile, Colombia, Congo, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Eswatani, Ethiopia, Europe, Faroe Islands, Gambia, Georgia, Ghana, Greenland, Guatemala, Guyana, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ivory Coast, Kenya, Kosovo, Kuwait, Lesotho, Lebanon, Liberia, Libya, Malawi, Malaysia, Maldives, Mali, Mauritius, Mexico, Moldova, Mongolia, Morocco, Myanmar, Namibia, Nepal, Nigeria, Norway, Pakistan,New Guinea, Philippines, Rwanda, Saint Vincent and the Grenadines, Serbia, Seychelles, Sierra Leone, Somalia, South Korea, South Sudan, Sri Lanka, Sudan, Suriname, Taiwan, Tajikistan, Thailand, Timor Leste, Uganda, Ukraine, UK,



Name: Moderna
Type : mRNA-based vaccine
Developed By : Moderna, BARDA, NIAID
Country of Origin : US
Authorized for use in : Andorra, Canada, European Union, Faroe Islands, Greenland, Iceland, India, Israel, Liechtenstein, Mongolia, Norway, Qatar, Saint Vincent and the Grenadines, Singapore, Switzerland, United Kingdom, United States, Vietnam

Name : COVID-19 Vaccine Janssen
Type : Non-replicating viral vector
Developed By : Janssen Vaccines (Johnson & Johnson)
Country of Origin : The Netherlands, US
Authorized for use in : Andorra, Bahrain, Brazil, Canada, Colombia, European Union, Faroe Islands, Greenland, Iceland, India, Liechtenstein, Norway, Philippines, Saint Vincent and the Grenadines, South Korea, Switzerland, Thailand, Tunisia, US, WHO

Vaccine Inforgraphic

Information from: https://www.raps.org/news-and-articles/news-articles/2020/3/covid-19-vaccine-tracker

Name : Sputnik V
Type : Recombinant adenovirus vaccine (rAd26 and rAd5)
Developed By : Gamaleya Research Institute of Epidemiology and Microbiology
Country of Origin : aRussia
Authorized for use in : Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahrain, Belarus, Bolivia, Congo, Djibouti, Egypt, Gabon, Ghana, Guatemala, Guinea, Guyana, Honduras, Hungary, India, Iran, Iraq, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Laos, Lebanon, Mali, Mexico, Moldova, Mongolia, Montenegro, Morocco, Myanmar, Namibia, Nicaragua, North Macedonia, Pakistan, Palestine, Panama, Paraguay, Republika Srpska, Russia, Saint Vincent and the Grenadines, San Marino, Serbia, Slovakia, Sri Lanka, Syria, Tunisia, Turkmenistan, United Arab Emirates, Uzbekistan, Venezuela, Zimbabwe

Name : EpiVacCorona
Type : Peptide vaccine
Developed By :Federal Budgetary Research Institution State Research Center of Virology and Biotechnology
Country of Origin : Russia
Authorized for use in : Belarus, Russia, Turkmenistan

Name : BBIBP-CorV
Type : Inactivated vaccine
Developed By : Beijing Institute of Biological Products; China National Pharmaceutical Group (Sinopharm)
Country of Origin : China
Authorized for use in : Afghanistan, Algeria, Angola, Argentina, Bahrain, Belarus, Bolivia, Brunei, Cambodia, China, Egypt, Ethiopia, Equatorial Guinea, Gabon, Guyana, Hungary, Iraq, Jordan, Kyrgyzstan, Laos, Macau, Maldives, Mauritania, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Nepal, Niger, Pakistan, Peru, Senegal, Serbia, Seychelles, Sierra Leone, Somalia, Sri Lanka, Sudan, UAE, Venezuela, Zimbabwe

Name : Covaxin
Type : Inactivated virus
Developed By : Bharat Biotech in collaboration with the Indian Council of Medical Research.
Country of Origin : India
Authorized for use in : India, Iran, Zimbawe,Mauritius, Nepal, Paraguay, Mexico, Philippines,Gautemala,Nicaragua,Guyana,Venezuela, Botswana

Name : CoronaVac
Type : Inactivated vaccine (formalin with alum adjuvant)
Developed By : Sinovac
Country of Origin : China
Authorized for use in : Albania, Azerbaijan, Bolivia, Bosnia and Herzegovina, Brazil, Cambodia, China, Chile, Colombia, Dominican Republic, Ecuador, Hong Kong, Indonesia, Laos, Malaysia, Mexico, Pakistan, Panama, Paraguay, Philippines, Thailand, Tunisia, Turkey, Ukraine, Uruguay, Zimbabwe

Information from: https://www.raps.org/news-and-articles/news-articles/2020/3/covid-19-vaccine-tracker

Silver Nanoparticles: A New Era

Photo by CDC

Research In Pilani: In talks with Dr. Jitendra Panwar

While most bacteria are very good for our bodies and are necessary, some are pathogenic and invade our bodies and make us sick. To deal with these pathogenic microbes, antibiotics have been utilized for a long time. However, with the increasing and improper use of antibiotics, bacteria have found a way to evade these antibiotics through the natural selection of genes that confer antibiotic resistance to them. This has been possible in a short period of 100 years as the generational period of bacteria is far shorter than the generational period of larger organisms. Hence, in bacteria, mutations accumulate much faster, some of which end up being useful for their survival like antibiotic resistance leading to more and more antibiotic-resistant microbes. These circumstances have led scientists to find alternative antimicrobials.

Written By Simran Sodhi and Kirat Chawla

Metals as alternates

To find alternatives for antibiotics or synthesize antimicrobials, it is important to know how the conventional antibiotics operate against the bacteria.

Antimicrobial agents have one of two activities. They can be either bacteriostatic or bactericidal. As the name suggests, bacteriostatic implies that these agents act to stop the growth, which is done by halting the production of certain factors essential for growth of the bacteria, whereas bactericidal are the ones which kill the bacteria.

Metals essential for various cellular processes are usually lethal at higher concentrations and hence usually have a bactericidal effect on bacteria. Especially some such as silver, mercury, and tellurium are poisonous to most bacteria even at extremely low concentrations.

This has probably been known since ancient times as silver has been used for its antibacterial properties for a very long time. Possibly, this is the reason why royalties used silverware. Drinking out of a silver glass leaves traces of silver in the liquid that acts as an antibacterial agent.

It was found that certain metals inhibit metabolic pathways in a selective manner and kill multidrug-resistance bacteria. Different metals have different mechanisms of actions, but mainly the way they attack the bacteria is by leading to protein dysfunction, producing ROS (reactive oxygen species) and depleting antioxidants, therefore, causing oxidative stress in the bacteria, impairing membrane function, interfering with nutrient assimilation or being genotoxic.

In the past few years, a variety of new silver formulations have been developed to deal with pathogenic bacteria. However, cost concerns and reports of silver-resistant bacterial strains have limited the use of silver as an alternative.

The advent of Silver Nanoparticles

The aforementioned issues with using silver as an antimicrobial agent led to the combined application of biology and nanotechnology, giving rise to silver nanoparticles as most biological processes happen at the nanoscale.

Silver nanoparticles (AgNP) are tiny silver particles that can diffuse into cells because of their extremely small size. Using silver nanoparticles is particularly advantageous as compared to their bulk counterpart because their small size confers a high surface area to volume ratio that provides better contact with microorganisms. Also, it has been shown in studies that silver nanoparticles restrict microorganisms to develop resistance. Additionally, while they are non-toxic to human cells at low concentrations, they can disrupt a bacterium's essential functions, thus acting as a bactericide.

Dr. Jitendra Panwar of BITS Pilani, who has been working in this field, determined whether physico-chemical properties of these silver nanoparticles had an effect on their efficacy as antimicrobial agents and found a result in the affirmative. This also leads to new design possibilities of AgNPs, which can be utilised to create even more effective bactericides. Among these factors, surface coating of AgNPs serves as the most important parameter and determines the nanoparticle microbe interaction. Depending on the type of coating, their ability to act as bactericides can be hindered or amplified.

To control the size of the nanoparticles, capping agents or protein caps are used, which do not allow these particles to clump together. AgNPs are suspended in a solvent, which is aqueous in most cases and so the protein caps also make the particles more soluble, thereby providing more stability to the colloid that is formed. However, Dr. Panwar found that these protein caps hinder the functioning of the silver nanoparticles.

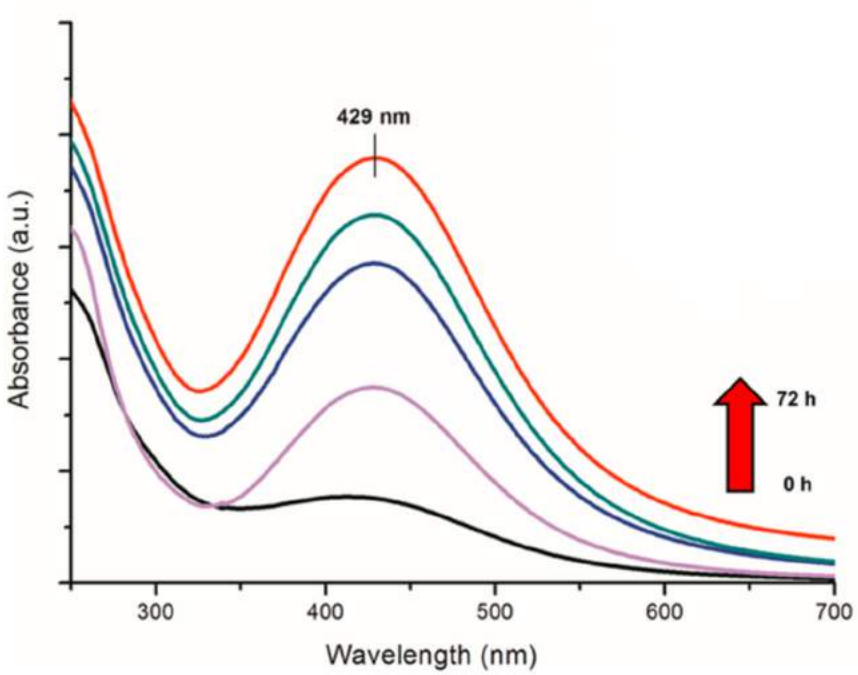


Fig 1. UV visible spectrum of reaction medium as a function of time (0, 12, 24, 48 and 72 h). Inset shows tubes containing fungal cell-free filtrate (a) without and (b) with silver nitrate solution after 72 h of reaction.

Comparing protein capped and bare silver nanoparticles

For the experiment, silver nanoparticles with the protein cap were synthesised using a one-step protocol. They harvested the fungus Aspergillus. Its extracellular secretions served as the medium where the reaction to convert silver nitrate to protein-capped silver nanoparticles was performed. A gradual change in the colour of reaction medium (containing fungal cell-free filtrate and precursor silver ions) from colourless to reddish brown serves as the indicator of silver nanoparticle synthesis. This method is very special as it is direct, simple, and environment friendly. Researchers produced the bare AgNPs by centrifuging the protein-capped ones. As research on AgNPs in medicine proceeds forward, a more straightforward and environment-friendly way to make them will indeed prove very helpful.

The experiment was conducted by studying the bacterial growth rate in the cultures of three different bacterial species. All the experiments showed a significantly higher growth rate in the cultures that were introduced to nanoparticles with protein capping.

It was also seen in a series of experiments that bare AgNPs produced a lot more reactive oxygen species (ROS) and more membrane leakage than protein capped ones. In aerobic conditions, it was also observed that bare AgNPs allowed the release of more Ag+ ions being released. These positively charged ions form electrostatic interaction with the negatively charged cell wall of the bacteria and moreover interact with the bacteria in such a way that leads to cell distortion and death. All these are probable mechanisms for the antimicrobial activity of silver nanoparticles and so they agreed with the result of protein-capped AgNPs not being as efficient in this ability.

It is the first study that shows the drastic effect protein-caps have on the anti-bacterial activity of the AgNP. This research shows that surface modification on the particles can be used for their functional modifications. Regulating their activity can prove very helpful in the future as they are further manipulated for this purpose.

RESEARCH IN FOCUS

The maternal microbiome modulates fetal neurodevelopment in mice

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Check for updates

Helen E. Vuong[1,2], Geoffrey N. Pronovost[1], Drake W. Williams[2], Elena J. L. Coley[1], Emily L. Siegler[1], Austin Qiu[1], Maria Kazantsev[1], Chantel J. Wilson[1], Tomiko Rendon[1] & Elaine Y. Hsiao[1]

'Dysbiosis' of the maternal gut microbiome, in response to challenges such as infection[1], altered diet[2] and stress[3] during pregnancy, has been increasingly associated with abnormalities in brain function and behaviour of the offspring[4]. However, it is unclear whether the maternal gut microbiome influences neurodevelopment during critical prenatal periods and in the absence of environmental challenges. Here we investigate how depletion and selective reconstitution of the maternal gut microbiome influences fetal neurodevelopment in mice. Embryos from antibiotic-treated and germ-free dams exhibited reduced brain expression of genes related to axonogenesis, deficient thalamocortical axons and impaired outgrowth of thalamic axons in response to cell-extrinsic factors. Gnotobiotic colonization of microbiome-depleted dams with a limited consortium of bacteria prevented abnormalities in fetal brain gene expression and thalamocortical axonogenesis. Metabolomic profiling revealed that the maternal microbiome regulates numerous small molecules in the maternal serum and the brains of fetal offspring. Select microbiota-dependent metabolites promoted axon outgrowth from fetal thalamic explants. Moreover, maternal supplementation with these metabolites abrogated deficiencies in fetal thalamocortical axons. Manipulation of the maternal microbiome and microbial metabolites during pregnancy yielded adult offspring with altered tactile sensitivity in two aversive somatosensory behavioural tasks, but no overt differences in many other sensorimotor behaviours. Together, our findings show that the maternal gut microbiome promotes fetal thalamocortical axonogenesis, probably through signalling by microbially modulated metabolites to neurons in the developing brain.

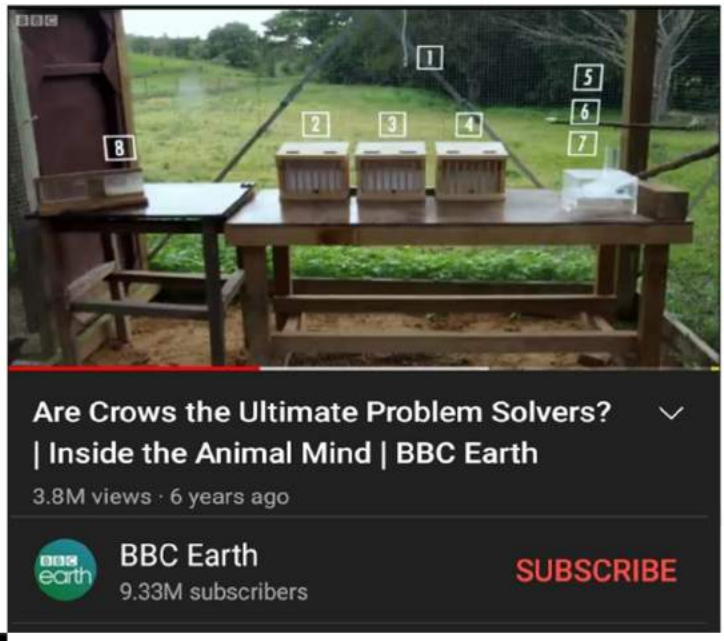
While it is established that microbiomes housed in different parts of the body affect our health, this paper explores how maternal microbiome can impact fetal development, giving exciting insights into how it steers the child's neurodevelopment. The study by Vuong et al on mouse models showed that even in the absence of stressful conditions, maternal gut microbiota regulate fetal brain metabolites that control axon formation. It also shows that the fetal microbiome is closely influenced by the maternal one; hence influencing the metabolites the fetus can utilize. The findings also support the evidence that malnutrition-induced alterations in maternal microbiome can cause reduced white matter even in the brains of adolescent and adult offspring, pointing to the importance of proper maternal nutrition and care during pregnancy.

Written By Gayathry Rajeev

BioTube

Inside the Animal Mind

In this series, researchers/scientists try to dive deeper into the animal brain and its functioning with special focus on their 'smartness' factor. They try giving different levels of complex tasks to different subject species, and then observe their reactions, the time taken and their ingenuity with hope of unlocking their secrets that we had never paid attention to before.

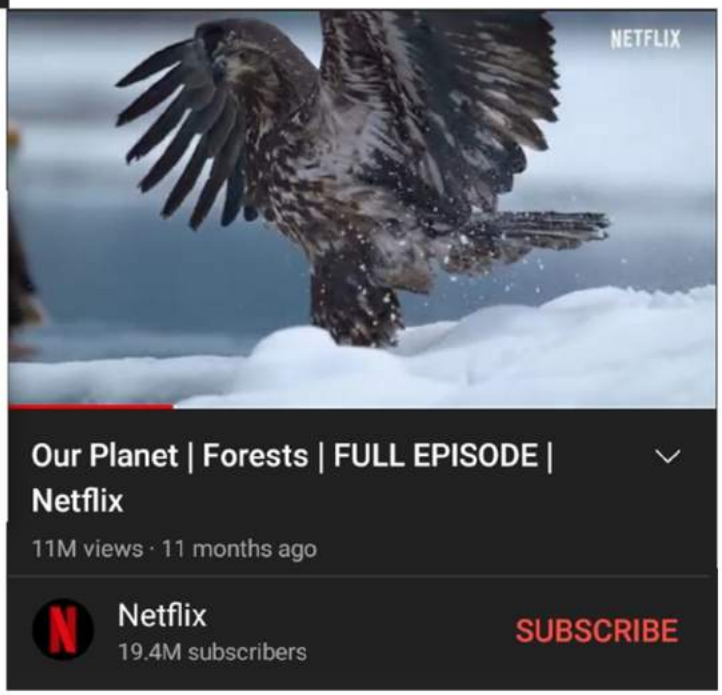


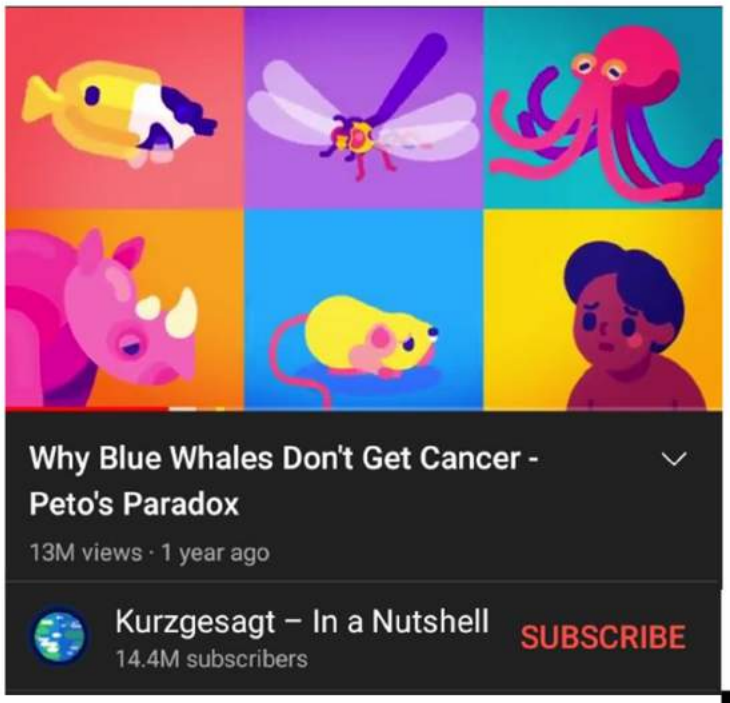
Panda Nursery

This show throws light into the efforts that are being put to save Panda's, the giant friendly bears which is on the brink of extinction. It shows how vulnerable the panda's are, especially the newborns, so much so that they need the care of both humans and Pandas alike. This show covers the upbringing of the Giant Panda twins in the valleys of China.

Our Planet-Forests

When the worlds largest streaming service decides to cover the remote parts of our planet, documenting the wildlife, It is something to look forward to. This show does just that, and much more. The scenic and breathtaking views are truly a treat for the eyes and provides insights into the lives of animals like Siberian tigers and Bald eagles.





Why Blue Whales don't get Cancer- Peto's Paradox

Cancer has plagued human beings since time immemorial. The risk of developing cancer should theoretically increase with both the number of cells and the lifespan of an organism. However , biologist Peto , after whom the paradox is named ,discovered that larger animals are at a substantially lower risk of developing cancer causing cells. Surprised , much ? Click on the link below to know more.

Bacteria could someday power our cells

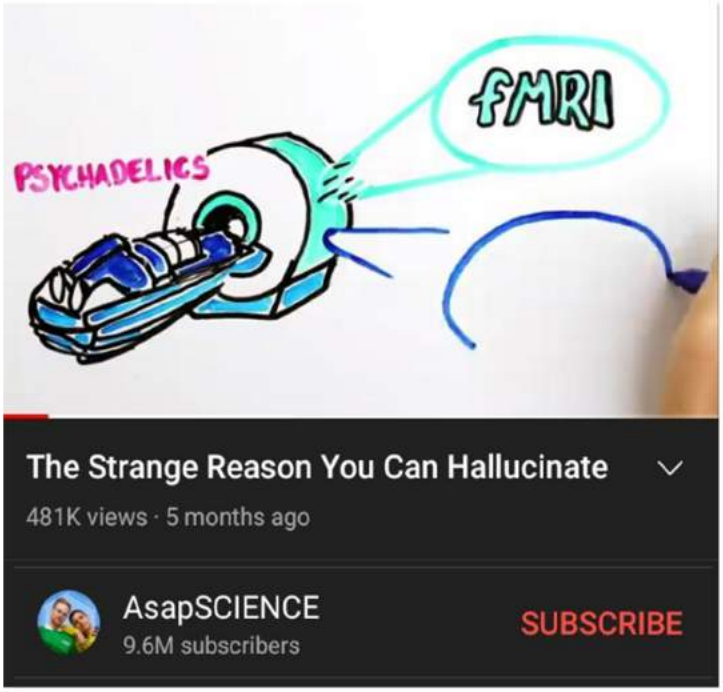
Bacteria are single cell microbes. Some bacteria are harmful but most serve a useful purpose. New uses of bacteria are being actively discovered all the time and scientists have recently discovered that not only are there are species of bacteria that can more or less harness electrons directly but can even move them around. Watch the video if curious !

What can DNA tell us about our ancestry ?

Two sisters take the same DNA test. The results show that one sister is 10% French, the other 0%. Both sisters share the same two parents, and therefore the same set of ancestors. So how can one be 10% more French than the other? Dig into the science of how ancestry DNA tests work, their accuracy, and why tracing ancestry is so complicated in this video .

The Strange Reason You Hallucinate

Our brain is a very strange organ and works in a way beyond our comprehension. Hallucination is one of the various weird ways our brain works. Hallucinations are sensations that appear to be real but entirely exist within the construct of our brain. We might just be essentially hallucinating our own reality all the time. Watch the video to know more.

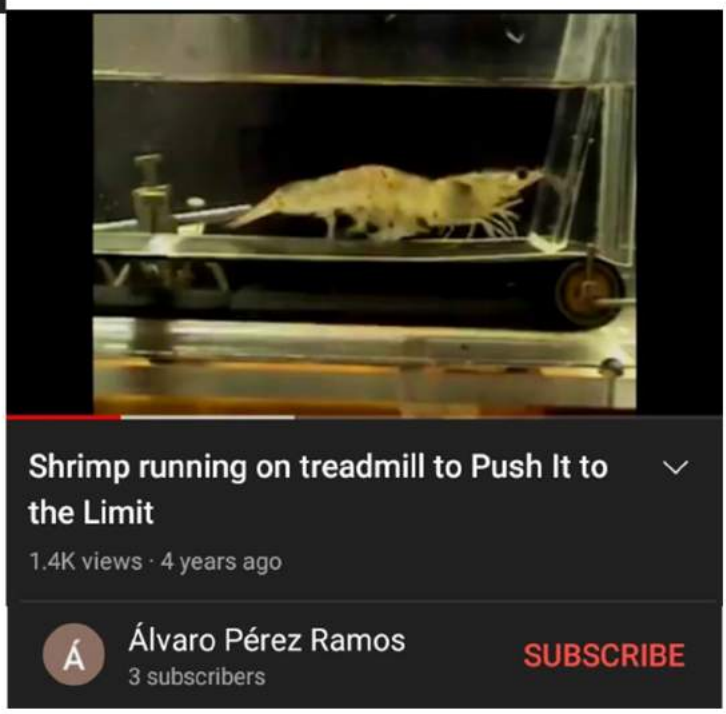


Immune Cell Chasing a Bacterium

It may look like the predecessor to Pac Man, but this vintage clip shows a neutrophil wending its way through a crowd of red blood cells to destroy its bacterial nemesis.

Shrimp Jogging on a Treadmill

While comparing the stamina of sick shrimp to their healthy brethren, scientists filmed this video of a cute little crustacean running on a treadmill. They found the four inch long shrimp could move at speeds of 66ft per minute and that it was able to continue for three hours before needing a rest.



The pink vial that you see in this picture has one million copies of the first biohackers episode.

REVIEW:

"Biohackers" – catchy title, yes. But how interesting is a fiction that begins with an animated DNA in its introductory credits? Well, it is a German series streaming on Netflix (spoiler alert). The first episode of the series had the protagonist chasing green mice glowing in a pitch-black room. If this doesn't remind a Science buff of green fluorescent protein and intrigue them, then what would?

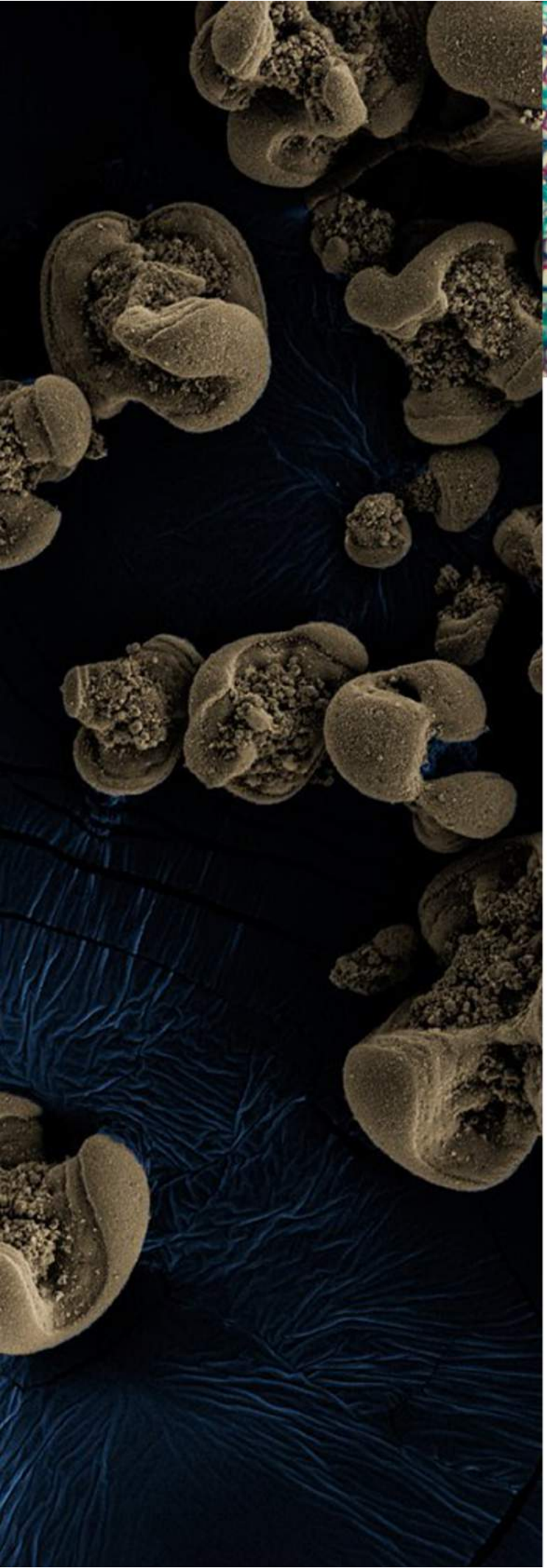
The series revolves around Homo Deus - a "thought to be failed" mission of a renowned scientist to develop illness-free babies by gene therapy. It has the elements of a well-made story and science in the most presentable proportion – suspense, revenge, secrets, romance, humour, plot twist, technology, logic, experiments, explanation and revelation.

Poster from Netflix

Poster from Netflix

Biohackers portrays the dream of every researcher to set their own lab up (can be a cabin in the woods or an incognito underground research centre, still a lab, right?) and carry out their own experiments happily. Partying with flouro-powders, rearing plants that taste like delicious meat, performing PCR like a pro (which of course happens ONLY in a series) – the biologists in the story are basically from a fantasy land, that we all wish were real.

Still not motivated to login to your borrowed Netflix account? Then you should know that this series is stored within the sequences of DNA. Yes, you read that right. The series is initially coded into 0s and 1s using a computer, the coded digits are then converted into the DNA bases A, T, G and C. Using stabilizing beads, the DNA sequences are stored like artificial fossils!! This reiterates the fact that nothing is impossible with science and whatever is being demonstrated in the series is not just a work of fiction or something that is far into the future.



Metal Bacteria

Written By
Kapil

A microbiologist unable to clean a jar, left it covered in manganese carbonate, a pink coloured compound, in a sink to soak. Only ten weeks later, he found something remarkable and historical that would probably change the careless ways factories and garbage disposals handle waste. The discovery was not at all pink but rather a dark, crusty substance something that resembled manganese oxide! If you are wondering whether tap water could induce the reaction, you are not alone!

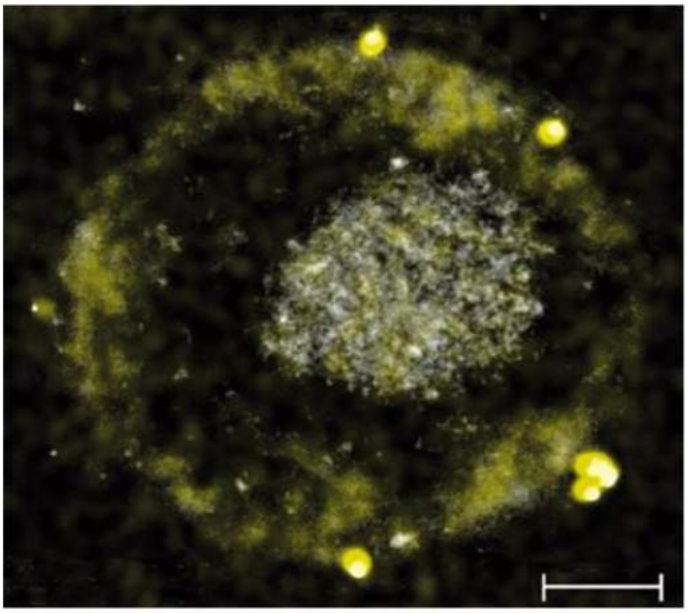
The conditions are far too unfavourable to show results of this magnitude and that's what stroke the curiosity of Jared Leadbetter, an environmental microbiologist as Caltech. To be sure that this is biological discovery and not chemical misunderstanding, Leadbetter and his team coated more jars with $MnCo_3$ and sterilized it with some scorching steam ($MnCo_3$ was quite stable in that temp). The compounds that were not sterilized with steam but infected with the tap water turned dark while the other remained the same even after a year! Clearly, our catalyst here is something that was destroyed in the hot steam bath. All misunderstandings clear, the team cultivated the life that was beaming in the jars and came from the tap water. RNA analysis confirmed 70 species, but as further tests ruled out possibilities, only two newly discovered bacteria remained and were christened as *Candidatus Mananitrophus noduliformans* and *Ramlibacter lithotrophicus.*

Scientists had long predicted manganese, the 12th most abundant element in earth's crust as a metal significant in bacterial biochemistry but had no proof, until now. These chemoautotrophic microorganisms extremely depend upon Mn (II) oxidation for carbon fixation as was observed by the isotope probing with $13CO_2$.

We apologise for describing this as a "historical" discovery in the beginning cause it's not. Metal eating bacteria are not uncommon. One of the famous ships (can you guess?) rusts and dissolves away at the bottom of the sea due to a bacterium called Halomonas titanicae. First sampled from the icicle-like formations of rust in 1991 but was not identified until 2010.

However, this bacterium is not without its benefits. While many authorities argue that RMS Titanic in future could be a great sight for tourists and scientists alike and these bacterial growths must at all costs be stopped, it is important to realise the potential- recycling of iron structures at certain depths and disposal of old naval merchant ships and oil rigs that are cleared of toxins and submerged as the ocean takes care of it- that this bacterium presents as well. Apart from cinematic ships and sinks metal consuming and degrading, bacteria are a great leap in metal extraction and purification processes.

The high demand and ever-rising prices of gold has necessitated for a more precise and exhaustive procedure that could provide profitable results in low-percentage ores. But the ever more pressing concern is the process at hand.



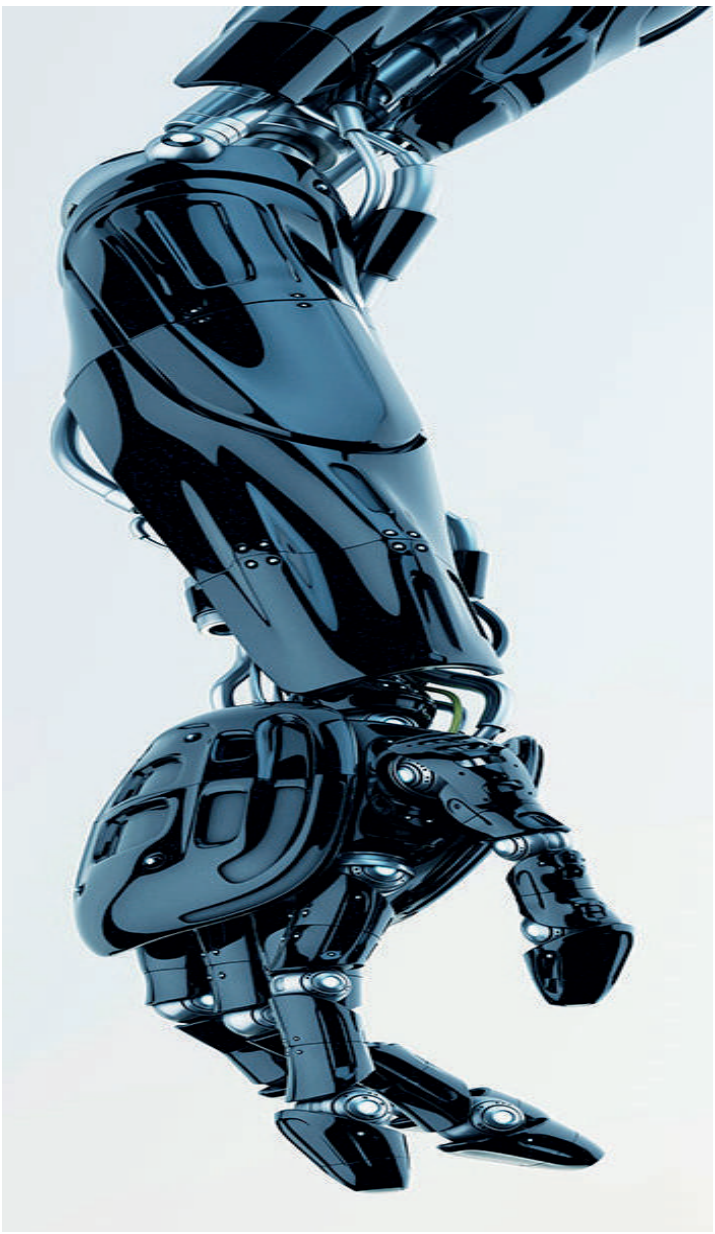
Mercury Amalgamation is a century-old process is still in use and is widely deployed for gold extraction however this mercury gets converted into toxic Methyl mercury and enters the food chain. Researchers have created genetically modified bacteria that could not only survive very lethal doses of mercury but also, convert this into a non-toxic form! Not only that there are bacteria that release enzymes that stabilize gold particles and dissolve them in colloids and complexes (imagine the possibilities if one could perfect this process!).

Rapid industrialisation has not only forced our hand at finding more effective pollution control measures but also finding more enriching and efficient metal extraction process to meet the growing markets' demands. Unmanaged use of agro-chemicals, fossil duel burning and dumping of sewage waste have caused soil and waterways contaminated with heavy metal like copper, chromium, manganese, lead and mercury. These pollutants are very slow degradable and persist in the environment as it slowly creeps into our food chain. Usage of chemicals only to treat these silent killers is not only further disrupting our natural chain of events but also are not that efficient hence, a call for more bio-positive green-chemical methods are the need of the hour and demands more extensive research.

CROSSING LINES

Civil: Photo-thermal energy optimization

Making efficient models for collection and usage of solar energy has been very essential for building green cities. Scientists have developed fibres and thermal collectors that are inspired from polar bear hairs. Evolution has gifted polar bears with an advanced mechanism to collect heat to survive in cold temperatures. They have been focused on because of the suitable structural and optical properties. On observation of a hair under the microscope, it is noted to be hollow inside with a rough inner core. These features double the collection efficiency thus giving us inspiration to make technology from the sa me. Study of designs from organisms and applying it to man-made apparatus is often done in civil sciences including efficient building designs based on ant hills.



Mechanics:

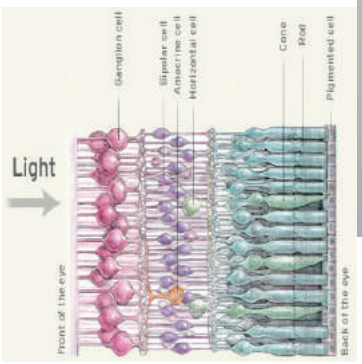
Normal prosthetic limbs are passive. The wearer needs to expend extra energy just to move these hard pieces of plastic. These limbs don't provide any articulation at all. Nowadays, many prostheses are coming into the market that supplement the wearer's actions like an actual limb does. iWalk, co-founded by Hugh Herr, an engineering professor at MIT, specialises in making bionic prosthetic legs that use motors how our body uses muscles. These legs can be controlled, just like how one would use their own legs by converting the electrical stimulus in our body as input for the artificial leg. iWalk has even developed an amputation method called AMI, which can help the amputees receive certain sensory information from the leg.

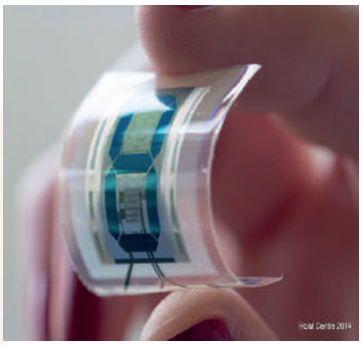
As great and inspiring the bionic lambs are, one cannot ignore that these limbs cost a lot to make and attach to the wearer. This is where another type of prosthetic, hands made by Guillermo Martinez, don't have motors that provide power to move; instead, they use high tension strings that help the 3-D printed hand contract when these strings are pulled while moving the arm.

Bio-Electronics:

There has been a lot of research going on in the interdisciplinary field of bioelectronics of late. Late in 2013, the first ever bio-FET or biologically sensitive Field effect Transistor was made. These are variations of normal Fets, specifically MOSFETs (Metal-oxide FET). They can be used in various fields such as immunobiology, DNA technology, cell/ protein monitoring, etc.

Recently,in October this year, nano bio-FETs were developed for biomolecule identification, to make the process of identification, extraction and purification easier for scientists. The working is based on the fact that biomolecules are charged and can influence the transistor to behave in a particular manner and the transistors are highly specific, making them highly sensitive. They are now being developed to be used in live cells to monitor the effect of different proteins, and possibly even drugs, which would make the process of drug testing far more efficient and economic than it is today.



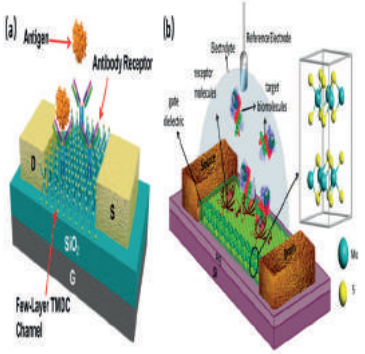


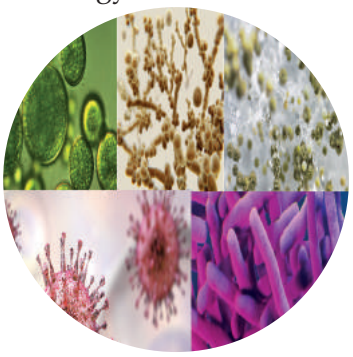
Bioinformatics:

Loss of retinal ganglion cells in the retina is the leading cause of permanent blindness. These cells have limited capability to regenerate making transplants from deceased donors infeasible. However, stem cells differentiating into the retinal cells can be used to restore the vision, however, identification of these cells was an error prone process. A neural network model- a computer algorithm that mimics the way neurons in the human brain work- to identify the differential stages of the stem cells as they grow into retinal cells was developed. The neural network was fed with some predetermined images and a number of experts identified the differentiated cells in some 1200 images to train and test the predictions. With 87% accuracy this neural network model successfully identified the fully differentiated retinal cells compared to humans who had only 64% accuracy. It is hypothesized that there will be other structures and morphological features that will give clues in more efficient and faster predicting of early retinal cell development. Furthermore the advantage of being able to transplant these cells far outweighs the current disadvantages.

Bio-geo-sciences:

Bioaerosols are particles released by the biosphere such as pollen, spores or fragments of living tissue. Bioaerosols vplay a vital role in the exchange of genetic material across distances and helps to maintain the biodiversity and life cycles of organisms. Samples collected from the atmosphere are often analyzed to understand the emission, transport and changes of these particles over the course of time. The effect of climate on bioaerosols and vice-versa is a growing field in order to determine effects of climate change and vice-versa. The study would require extensive and efficient methods for sampling, identification, testing for parameters such as metabolic activity, viability, understanding changes in those parameters owing to change in seasons and climate and developing models and simulations to understand the extent of the effects of climate on the bioaerosols. Bioaerosols might prove to be biomarkers to understand the extent of climate change and maybe lead to adaptive measures of technology to stabilize the changing biosphere. It would require an interdisciplinary approach from biologist, chemist, physicist, geoengineers etc. to come up with technology for the same.

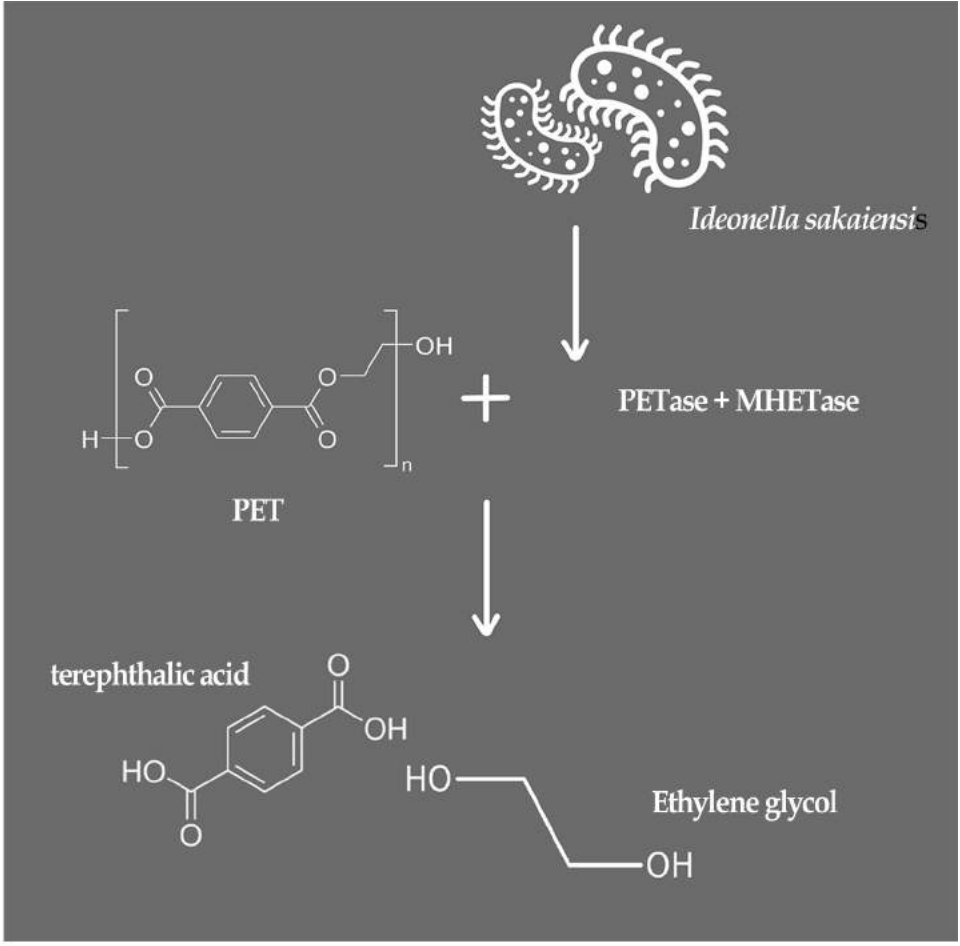




Bio-medical:

Organic semiconductors provide compelling alternatives for bio-integration compared to inorganic semiconductors. They offer a wide range of highly useful features for bio related applications, including mechanical flexibility, tailorable optoelectronic properties, low temperature solution processing, lightweight, and good biocompatibility. Importantly, the performance of organic electronic devices such as organic thin-film transistors (OTFTs), organic LEDs (OLEDs), organic solar cells (OSCs), and organic photodetectors (OPDs) have been improved dramatically in recent years. For example, power conversion efficiencies (PCEs) of OSCs have been increased from less than 5% in 2005 to over 17% in 2018 while OLEDs have been commercialized by Samsung and LG for use in flexible displays. Currently, there is a lack of mechanistic models to fully understand the organic device-biological interface. Synergistic efforts from chemists, engineers, device physicists, and biologists are crucial to making further progress in this highly interdisciplinary area.

MOLECULES YOU SHOULD KNOW ABOUT



Trehalose:

Tardigrades are a group of microscopic, eight-legged animals that are well known for their incredible ability to thrive in the harshest of conditions- be it lack of oxygen, water or even very low temperatures. They do so by curling up into a tiny ball called a tun and entering a state of dormancy when its metabolism drops down to 0.01% of normal. This is called cryptobiosis and it is made possible by a sugar called trehalose, which stores up all the water within the tardigrade. In this way, the genetic material is protected from degradation. Trehalose is also used commercially in the food industry and in biopharmaceutical formulations.

PETase

In 2016, a team of Japanese researchers discovered a new species of bacteria, Ideonella sakaiensis, that feeds on PET(polyethylene terephthalate)) plastic. Further studies indicate that an enzyme present in the bacterium called PETase hydrolyses PET plastic into its monomer, which is further broken down by another enzyme called MHETase into terephthalic acid and ethylene glycol. However, since the natural process carried out by Ideonella sakaiensis is too slow for industrial operations, researchers are attempting to synthesize a more suitable version of PETase. If they are successful, then it could truly be a game-changer for sustainable technology.

Microscopic image of a Tardigrade.
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Peter Von Bagh

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